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Reinforced Concrete Railway Bridge Floors.

The question of the best form of a substantial railroad bridge floor has not been satisfactorily answered by experience to the present time, except probably through the use of that almost universally applied structural material, reinforced concrete. It is possible that disappointment may be in store for those engineers who have been courageous enough to design a bridge floor of concrete-steel, but the results of experience with it in many other lines of application where trying duties demand enduring qualities certainly give material encouragement.

A railroad bridge floor carrying modern heavy high-speed trains must sustain the most severe usage to which any modern structural material is subjected. The members of other portions of a bridge receive the stresses due to the loading, in a measure indirectly. They are relieved by the elastic cushioning effect of other members between the points of application of the loading and themselves, from the immediate shocks of the rapidly passing trains. In other words, their loading approximates more nearly to the "gradually applied" kind. No such ameliorating conditions hold, however, for the floor members. All the pounding and shocks of direct blows from the train and locomotive wheels are delivered primarily on the floor, and these effects are frequently aggravated by imperfections of track. Any material adapted to these fatiguing and distinctive requirements must have extraordinary qualities of endurance both in tension and compression. There must be both a reasonably high ultimate resistance combined with toughness. Manifestly no unaided masonry employed by engineers at the present time can meet these exacting requirements.

If steel trough floors, of which there are a number of excellent types, are to be the real carrying members of a bridge floor, manifestly a concrete filling or immediate support or bed for the rails might be contemplated, but that would be no essential departure from the ordinary trough floor carrying ballast except the higher cost without corresponding compensation.

The advantage which a concrete bridge floor must disclose under suitable design, if it is to be successful, is its own carrying capacity as a beam. There are various possible arrangements of steel beams as transverse or longitudinal carrying members in the panels of a truss bridge or in plate-girder structures which afford suitable floor constructions of reinforced concrete, like those shown in the description of the Bay Ridge Improvement Bridges, printed in another column of this issue of The Engineering Record, or like other existing instances of actual construction. In this general class of design the concrete steel acts in every instance as the immediate carrying structure of the track, the rails frequently resting upon ties depressed into the concrete. If such a construction can be made with satisfactory results, both structurally and commercially, it will certainly possess some marked merits.

There are reasons why success may reasonably be anticipated in this application of reinforced concrete. These anticipations become almost certain of fulfillment if the requisite beam resistance can be secured without necessitating too large a mass of the reinforced material. Many tests and the results of actual experience in construction show that concrete-steel beams possess a high degree of toughness well calculated to resist the shocks of high-speed trains. There may be some room for apprehension that the frequent and continuous repetition of shock effects, especially of severity, may disclose a lack of endurance which has not hitherto been exhibited, although that is scarcely to be expected. In connection with this feature of the matter, it is to be observed that there will be no such single point of concentrated shock effect in the reinforced concrete mass as at the end of a longitudinal stringer in the ordinary type of steel railway bridge floor. The mass of reinforced concrete necessary in the most economical design, will act effectively in absorbing uninjuriously by its inertia, much of the shock of the moving load. This is, mechanically speaking, a substantial advantage and one which will go far with a reasonably smooth track toward dissipating the difference between the effects of gradually applied loads and rapidly moving trains. Indeed, it seems probable that the well built concrete-steel bridge floor may be found sustaining shock effects indefinitely with no visible evidence of deterioration.

The choice of method of carrying the rails is a matter of much importance. If the rail should be carried directly on the concrete with some suitable distributing steel member interposed it is possible that the shock effects may be materially greater than if the rails should be carried on timber ties depressed into the concrete mass with the resulting cushion of the timber fibres. This is a question only to be settled by actual trial and will probably have but little effect on the answer to the main question.

The indestructibility of the concrete-steel mass under any atmospheric influences and the economy with which such a combination of materials may be put in place at the present time, give to any railroad bridge floor construction of this kind, unusual interest. It would not be surprising to find actual experience in this direction opening an additional field of application for a structural material which has already had a remarkably successful, although as yet but a short record.

Specialization in Technical Education.

The extent to which specialization should be carried in engineering education is a question on which there is naturally considerable difference of opinion. This difference is, perhaps, more apparent than real, and prevails to a less extent at the present time than a few years ago. The curriculum is, after all, of less importance than the teacher, and with capable instructors the student will be well trained under a great variety of courses and programmes. It is probably true, however, that as engineers and educators are reaching a more clear understanding of those elements that go towards the making of a well-rounded engineer, the tendency of the courses of study is away from rather than in the direction of further specialization of the kind which has prevailed to some extent in the past. Much of this specialization has been superficial and almost valueless from an educational standpoint, but at the same time it must be said that it has been demanded to a considerable extent by engineers and has been exploited by inexperienced but enthusiastic teachers. It is a short-sighted policy for the civil engineering student, for example, even though he may have his career closely mapped out, to spend a large amount of time in the professional school studying details of special forms of bridges, or of falsework, or numerous designs of railroad standards; or for the electrical engineering student to devote his time to learning all about the details of telephone work or of dynamo design; or for the mechanical engineering student to consume valuable hours on impirical designs of machines.

The question of the legitimate extent to which a curriculum should lead in the direction of some special or narrow field of practice is one on which it is difficult to draw a hard and fast line. In the great majority of engineering schools, both foreign and American, we find more or less distinct courses in civil, mechanical, electrical and mining engineering. These courses usually begin to differentiate in the second year, but in some cases not until the third. In many schools some freedom of choice among various technical studies is allowed in each of the courses in the fourth year. It may, therefore, be said that it is the consensus of opinion among educators that specialization should be carried to the extent of differentiating the work somewhat into these general groups or courses. In a few schools the specialization is not carried even to this extent and undoubtedly the authorities of such institutions believe the best results can be accomplished by the methods they are following.

The young man who is intending to become an engineer should secure as broad a professional training as practicable, and undoubtedly the greater part of his engineering course should be devoted to a mastery of the fundamental principles underlying engineering practice. But a study of principle alone will not constitute a satisfactory or effective engineering course. To an engineer principles are of little value unless they can be applied effectively to the solution of practical problems, and a very considerable amount of time must be devoted to the application of principles not only to fix them in the mind of the student but to introduce him into the methods of the engineer in evaluating the relations of theory and practice. This practical part of the student's training can easily be carried beyond the economical point; but certain studies lend themselves much better to this work than others and can profitably be carried much farther without any reference whatever to the question of training the student specially for that particular field of practice. The several engineering courses as now generally provided are composed of groups of studies corresponding in a general way with the various divisions of practice. Each of these groups contains abundance of good material on which the student can profitably devote his four years if at the same time he does not neglect the fundamentals underlying all. To attempt to cover the applications in too many directions is apt to lead to a smattering of knowledge, and there seems to be good ground for specialization to the extent at least as is represented by the several standard courses.

Quite apart from specialization in technical details there is a legitimate field for special work in advanced study and research. For the average student who has completed his four-year engineering course the best thing is to enter at once into the active engineering or industrial world. The engineering sense must be cultivated by contact with actual problems in which the responsibility is felt such as it can be in no other way. In practice a thing must actually be done. Errors are of more consequence than where a recalculation is the only penalty, and nothing can give that incentive to do things right like the responsibility for actual work. For the average engineering graduate who has not yet found himself, a year of practice will probably be much more valuable than an extra year of study where he is likely to have no very definite aim and where he is apt to fritter away his time in doing so-called advanced work in design. There is, however, another class of students for which real advanced work of a scientific character is valuable. The development of applied science and the equipment of working laboratories for study and research in many of our universities and technical schools give opportunities for advanced and graduate study which to the right man are of great and practical value. While in certain lines of work greater demands are being made for executive ability it is equally true that in other fields modern conditions require more thorough scientific training. There are many opportunities in the industrial field for the use of the most thorough preparation that can be had, as for example, in those industries involving a special knowledge of chemistry, the electro-chemical industries, gas manufacture and utilization, and many special fields of electrical engineering. A more thorough scientific knowledge is also greatly needed with reference to materials of construction, experimental hydraulics, thermodynamics and other applied sciences. There are abundant opportunities for the best minds, and the mature student who is fitted for such work may well devote additional years to advanced study. The existence of a large percentage of graduate students in German technical schools, where the undergraduate course is already thoroughly developed, is an indication of the trend in this direction. While engineering practice in this country will doubtless be less closely bound to formulated theory than in Germany, it will at the same time always be ready to adapt itself promptly to advances in scientific knowledge, and there will be a wider field in the future for the student who has made some field of applied science, rather than details of practice, his special study.

Alcohol for Power.

Since the agitation which culminated in the free alcohol bill, the alcohol engine has attracted no little attention as a prime mover for small powers, but as yet there has been little actually done in the United States in the development of the machine or its use. It is in fact a far cry from the admission of denaturized alcohol free of duty to the practical employment of such alcohol on a large scale. In the beginning a new industry must be created, which is a process requiring some time. Denaturized alcohol, as most of the readers of this journal know, is merely ordinary, or ethyl, alcohol adulterated with some substance which renders it permanently unfit for use as an intoxicant. As used abroad, the added substance is commonly crude wood alcohol to the extent of about ten per cent., or sometimes pyridine in much less quantity, one per cent. more or less, the latter substance being of such offensive odor and taste enough to discourage even the most hardened toper. Alcohol so treated, however, is entirely suitable for most industrial purposes and as a substitute for petroleum oils in oil engines certainly has a future before it. So far as power production is concerned, only a small percentage of the total petroleum product is available since most of the oils obtained are of too high boiling point to vaporize easily. Hence the production of gasoline is limited and the increased demand of the past few years has raised the price considerably and must infallibly continue to do so, quite irrespective of any machinations of the oil trust.

Alcohol is not quite equal to gasoline in thermal energy, gallon for gallon In compensation for this it can be worked under somewhat greater compression in an internal combustion engine without danger of self-ignition, so that its heat energy can be rather better utilized. Just what the actual ratio in power capacity between alcohol and gasoline may be has not yet been fully determined. Some of the American experimenters claim a slightly better result from alcohol, while some of the German tests indicate a small advantage the other way. Much, of course, depends on the type of engine used, since the alcohol should be used at higher compression than is usually provided in standard engines. It seems at least highly probable that this very fact indicates somewhat greater capacity for an engine of given dimensions when using alcohol than when using gasoline. This gives an advantage in first cost and in weight which should be of some moment in automobiles, even supposing no gain in cost of fuel. The actual cost of alcohol fuel is a subject of very various opinions. Thus far there has not been a general demand for cheap alcohol in this country so that its manufacture has not at all reached a working basis. In Cuba and the other West Indies, spirits are generally cheap and alcohol has been down even to 12 cents per gallon. It can certainly be made from cheap grain and even from vegetable refuse at a very low figure, probably something of the kind just mentioned. Some figures even of 10 cents per gallon have been quoted, but these could not be reasonably expected to be reached save in case of a demand justifying manufacture on a very large scale. To the first cost must be added at least two or three cents per gallon for denaturizing, so that the actual price to the consumer cannot be expected to fall materially below the present cost of gasoline and for a time it will certainly run higher.

At equal prices the preference would, of course, be given to alcohol. It is much less dangerously explosive, has an inoffensive odor and above all it gives much cleaner combustion than gasoline, as is to be expected of a substance having a definite chemical composition and burning with a smokeless flame. For use in engines this clean combustion is very important and will tend greatly to decrease the trouble with sparking plugs and even with lubrication, which is rendered none the easier by the deposit of carbon from the fuel. The main requisite, now that cheap denaturized alcohol is to be available, is the production of engines specialized for its use and the establishment of distilleries or import agencies to ensure its being put on the market at a reasonable figure. At first it will come on the market at a much higher price than gasoline, and it will not come down until it is clubbed down. The engine builders and the automobile builders should take the initiative in bringing out alcohol engines, and this done cheaper alcohol would follow the demand. It would not be a bad thing presently for the Automobile Club of America to start the ball rolling by providing an official outlet for cheap Cuban denaturized alcohol as soon as a suitable number of alcohol-using cars appear. Sold to members at cost of importation it would very quickly bring down the price of the domestic article to a real competitive basis. Unless some such systematic effort is made, there is very likely to be a long period during which a combination of distillers will be able to hold up the price against importation on an ordinary commercial basis. Gasoline production is at the mercy of a monopoly and vigorous efforts should be made to prevent the competition of denaturized alcohol from being smothered or the product being practically in the hands of big producers and greedy middlemen. If engine builders and automobile users lend a hand there is a chance for a revolution in small prime movers, which should not be let go or missed for lack of active co-operation.

Some Features of the Estimation of Values of Water Supplies.

Advances made in improving the quality of public water supplies and the value which is placed upon improved qualities is forcibly shown by some features of a recent estimate made by a commission of engineers for the City of New York on the value of certain private sources of supply located on Staten Island and proposed to be purchased by the city with a view of making them parts of the public water supply of the City of New York. Although this commission reported in February of the present year, and the city has since that date purchased one of the sources of supply covered by the report of the commission at practically the latter's estimate, it is only recently that the report has been put in printed form for distribution.

Staten Island forms the Borough of Richmond of the present City of New York and some portions of it are covered by a close city population. Other parts are sparsely populated, and intermediate densities of population are found on other portions of the island. It is not the judgment of the commission that these sources of supply can be utilized for a long period of years in consequence of the comparatively rapid increase of population of the Borough of Richmond, but that they may be available under suitable conditions for the near future. Under such circumstances it is obvious that the estimation of the value of the sources of supply and the water works properties, including real estate, would be much more complicated than the ordinary case of water works valuation. The influence of the usual elements of an estimate of value of water works on Staten Island may be easily allowed for, although there may be legitimate differences of opinion as to the relative weights of such influences.

There are other elements in these cases, however, which the commission wisely took into consideration as affecting substantially the values of the yields of the proposed supplies. Inasmuch as the bulk of the Staten Island waters are not taken from very deep wells, it may readily be supposed that the influence of population on the quality of water would be evident from chemical examination, and that proved to be the case. The existence of sewers together with more elementary methods of disposing of waste products on such a populated area would contribute material quantities of contaminated liquids to filter into the ground and join rain waters in their descent from the surface to the substrata from which they are naturally pumped for the water supplies in question. This is particularly the case in those portions of the small water sheds which are more or less sandy in nature. Again the natural qualities of the substrata themselves of the Borough of Richmond and the subsurface encroachments of salt water on those supplies at the lowest levels, produce at points high degrees of hardness.

It is clear enough as a business proposition, and this part of the commission's work must be treated from a business standpoint, that supplies even slightly contaminated or subject to comparatively high degrees of hardness cannot have the same value as potable waters as those free from such objections. There may be a legitimate difference of opinion as to the decrease in value due to these elements, but there can be no doubt that the decrease should be material. The commission which was unanimous in its report, "Taking 50 parts per million as the normal hardness, approximately, of the other supplies," made "a deduction . . . of 10 cents per million gallons for each part per million in excess of 50." The normal value of water in the pipes was taken at $70 per million gallons, and the deduction for hardness as described before ranged from $4 to $13 per million gallons, depending upon location. A further deduction of $10 per million gallons was made in one case for salt and iron. It was necessary to allow for the influence of population of the water shed in two instances only, at the rate of $20 per million gallons in one case and $10 per million gallons in the other. The total deductions thus constituted ranged from a minimum of $4 in one case to a maximum of $43 per million gallons for that source located in the most densely populated district of all.

There is nothing new in making these deductions for quality, which in the one case amount to nearly two-thirds of the normal value of the water in the pipes, but the important part which these deductions play in the valuation of these particular waters, give the case prominence. It is clearly reasonable, and in fact absolutely necessary, to recognize the deteriorating influence of hardness and contamination. In fact, as these investigations show, the deteriorating influence of those elements might be so great as to destroy the value of the proposed source of supply. The presence of a high degree of hardness leads to a large additional expenditure for soap wherever a water so charged is used for laundry or other similar purposes. Similar results are produced by salt and iron. The cost of a contaminated source of supply in the effect on life and health to a community using it is practically past computation. Epidemics of typhoid and other water-borne diseases give sufficient emphasis to the latter feature of the matter to require no further comment.

The report of this commission, which appears to have attracted little or no popular attention, marks a most important procedure in the valuation of public water supplies, and it deserves a most careful consideration for this reason, if for no other. The treatment which the commission gave to its work is entirely fair to the owners of the supplies, as it is just and businesslike to the municipality for which it acted, and its recommendations should govern the purchases proposed to be made.

Notes and Comments.

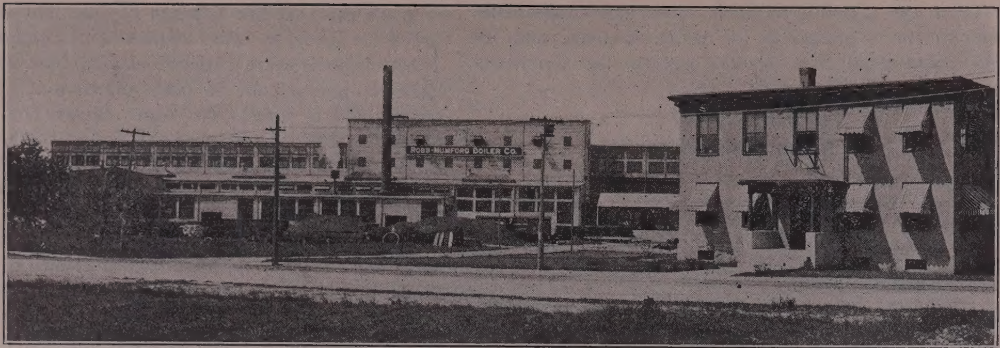
A Reinforced-Concrete Conduit, with an interior diameter of 12.5 ft. and operating under a water pressure of 92 ft., has been placed in service in an irrigation system in the Province of Huesca, Spain. The conduit is 3,330 ft. long and is in duplicate. The two pipes are estimated to supply nearly 10,000 gal. of water a second to a canal that will furnish water to irrigate 261,820 acres. They are built as inverted syphons across two valleys in lieu of an elevated aqueduct.

Road Metaling Material suitable for improving in a permanent manner all the more important highways of the state is abundantly supplied in Indiana, according to the recent report of Mr. W. S. Blatchley, state geologist. The material, moreover, is said to be well distributed, as only eight or ten counties in the northwestern portion of the state will have to import gravel, or stone for road building. Samples of limestone from seventy-two different localities of the state, when tested in the laboratory of the Office of Public Roads of the Government at Washington, show that with few exceptions the limestones of southern and central Indiana are well adapted for surfacing country roads and highways. This favorable report on the results of the investigations that have been made, coming as it does from one of the prairie states that has been generally considered to be practically without good road-making material in many sections, augurs well for the investigations that are being carried on in the neighboring states, and from the information that is already at hand it is reasonable to expect that similar results will also be obtained in the latter.

A Bridge Accident occurred in the harbor at Duluth, Minn., on the morning of Aug. 11, which temporarily cut off completely ingress to and egress from the inner harbor of that city. The steamer Troy, of the Western Transit Co., collided with the 501-ft. pin-connected draw span of the interstate bridge about 20 ft. to one side of the center pier at one o'clock in the morning. The end of the span that was struck immediately sank into the channel, and a moment later the other end of span collapsed and fell into the water, both ends maintaining an erect position. According to reports, both ends are at the present almost submerged. The end that was hit was badly broken, the deck of that portion being under water, while the superstructure was well down. The deck of the other end of the span was about flush with the water surface. The center pier was apparently not damaged. The bridge carried a double-track street railway line, two sidewalks, and had space for a double-track railway, which latter space had not been occupied. The accident tied 35 boats up in the inner harbor, and for the time being, stopped shipments from the Missabe ore docks, from the merchandise and flour warehouses of the Great Northern Ry., from many elevators and from several coal docks. The ore shipments alone through the obstructed channel amount to about 50,000 tons a day at this season. The cause of the accident has not been determined as yet, the captain of the steamer claiming he signaled for the draw to be opened when at sufficient distance from it for the operator to turn the span.

The Passing of the Iron Mountain in Missouri as a profitable source of iron ore has been marked by the recent dissolution of the Iron Mountain Co., a corporation formed 40 years ago to work the iron ore deposits of Iron Mountain and Pilot Knob, 80 miles southwest of St. Louis. These deposits were believed at that time to be large enough to make St. Louis the rival of Pittsburg, and to supply the iron industry of the United States for an indefinite period. The St. Louis & Iron Mountain R. R., which has since become one of the principal railway systems of that section of the country, was started by the prospect of traffic from these deposits. Blast furnaces were erected at Carondelet, a suburb of St. Louis, and large iron works were established at other points to utilize the ore from the deposits. As the working of the deposits proceeded, however, the Iron Mountain proved to be a surface deposit only, which was gradually exhausted. Explorations failed to show anything of value in depth, so the mines were abandoned one by one, until the output of ore was insignificant, and for some 10 years past has been nothing. The affairs of the corporation were honestly managed, and during the early days of the organization the stockholders received over 200 per cent. on the par value of their shares in dividends. The reasons given for dissolving the corporation are that it has not been actively engaged in business operations for a long time past and has no indebtedness; and the aggregate value of the assets has been reduced by depreciation in value of its real estate, to a small percentage of the capital stock.

The Reconstruction and Reinforcement of the Poughkeepsie bridge, described on another page of this issue, is a work of more than usual interest, both on account of its magnitude, the importance of the original structure, and for the ability and success with which the difficult operations are being executed. The Poughkeepsie bridge has long been famous for its height, length of spans and because it was one of the first examples of long-span, double-track railroad structures in this country, making it, when built, almost unique among bridges. The superstructure was designed about twenty years ago in accordance with the requirements then current for train loads, and without provision for future reinforcement. Since then the increasing demands of service have made it necessary to strengthen the structure greatly; the operations of reconstruction presenting problems much more difficult and perplexing than those of the original construction, which were sufficiently novel and costly. The sub-structure was of a character that has been deemed adequate for the increased service; but great changes, amounting almost to reconstruction, have been found necessary for the superstructure, and are being made at an expense and under difficulties which might have been greatly reduced if some provision for them had been made when the bridge was built, as might have been done without materiallly increasing the first cost. The omission of such provision, while it provides an opportunity for brilliant engineering work, should especially impress on present designers the importance of treating such structures so that opportunity can be provided easily for reasonable future extensions, or reinforcements, made substantially integral with the old structure without materially reducing the service of the latter while they are in progress. The replacement of a tall steel viaduct in the same position without the use of false work and without the interruption of traffic has been considered until recently so difficult as to be nearly, or quite, impracticable. The very successful method described elsewhere in this issue, and the equally able one recently adopted on the similar work of reconstructing the long and high trestles of the Rondout viaduct by the same engineer rank among the most difficult and important examples of bridge engineering.



General View of Plant, Office at the Right.

THE ENGINEERING FEATURES OF A RECENTLY COMPLETED BOILER SHOP.

A DESCRIPTION OF SOME OF THE ENGINEERING DETAILS OF THE NEW WORKS OF THE ROBB-MUMFORD BOILER CO.

By H. S. Knowlton.

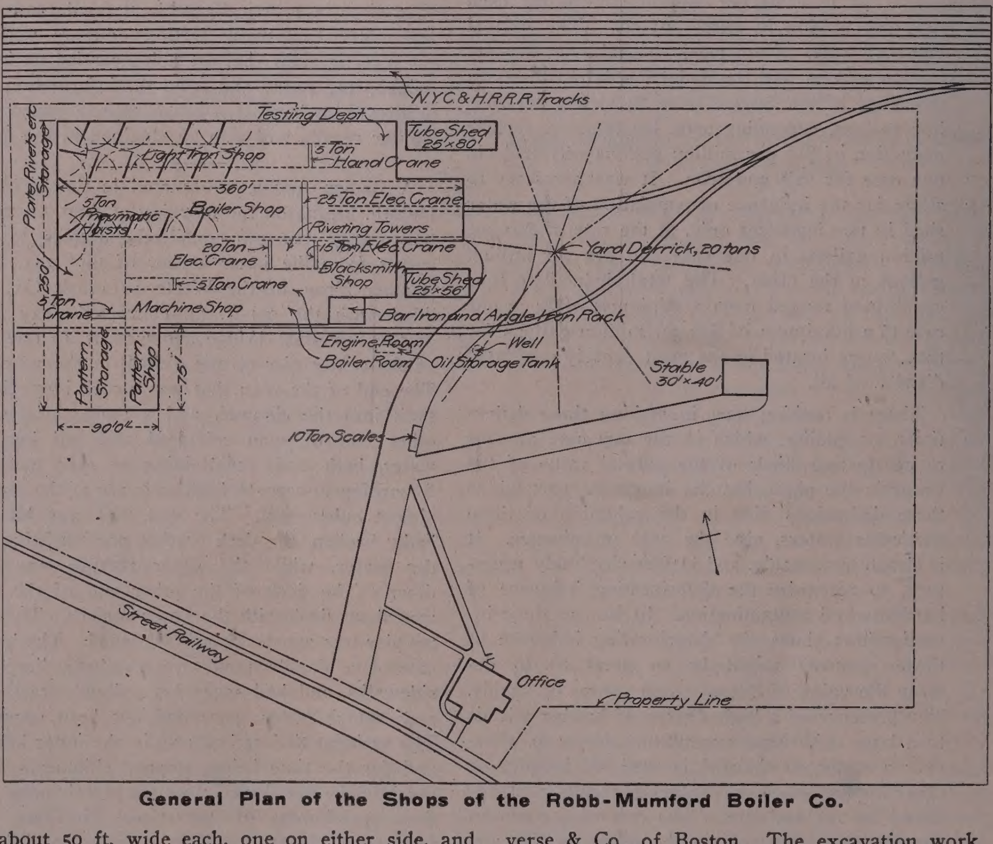
The new shops of the Robb-Mumford Boiler Co. at South Framingham, Mass., are of interest to the engineer as an example of an industrial plant in which economy of production has been the prime object in view in the design and equipment of each department. The plant represents a total investment of about $500,000. Its erection was necessitated by the inadequate facilities pertaining to the old establishment of the company in Cambridgeport, Mass., formerly owned by Edward Kendall & Sons and known as the Charles River Iron Works. Soon after the business of the Kendall organization was purchased by the Robb-Mumford Co., plans were drawn for a modern plant to be erected on the main line of the Boston & Albany R. R. at South Framingham, where the transportation facilities are much better than at Cambridgeport, and where the lower cost of real estate permitted a more liberal design of buildings and ample room for expansion in the future. The site chosen was a 10-acre tract of land on Waverly St., South Framingham, about one-half mile west of the retail business center of the town, and 25 minutes' ride from Boston by train.

The construction of the new shops was carried on while outside orders were being executed by the company, and the erection of the buildings, installation of new equipment and change of machinery from old to new foundations, involved the expenditure of much care and labor to avoid serious interruptions in the regularity of the company's output. As fast as conditions permitted, tools were set up in the new plant and manufacturing carried on, so that several months before the works were actually completed, the company's product was being turned out at the new site.

General Plan.—The accompanying general plan shows the location of buildings, general arrangement of departments and transportation facilities of the works. The plot of land included has a maximum length of about 800 ft. and a maximum width of about 580 ft. Facilities for receiving and shipping material are provided by about 1,200 ft. of side track connecting with the Boston & Albany line of New York Central R. R. One branch of the side track is carried through to the west end of the property and devoted to the delivery of raw materials at various points en route. The other branch extends 120 ft. into the main boiler shop, and is used only for the shipment of finished products.

A steel frame covered by reinforced-concrete construction was employed in the main shops, which are 360 ft. long by 250 ft. wide, over all; the walls are of concrete in the proportions of 1 : 2½ : 5, and are 5 in. thick. They are reinforced by ½-in. round steel rods, placed 12 in. apart vertically and 6 in. apart horizontally. The floor is of concrete varying in thickness from 6 to 8 in.; the roof consists of 4 in., of cinder concrete, reinforced with expanded metal supported by steel trusses. Concrete piers were used for the wall foundations and between each pier the wall is self-supporting. About 530 tons of steel were used in the frame of the building. The office building is a two-story frame structure, with concrete plastered on the outside and expanded metal lathing. It is approximately 40 ft. square, with masonry foundations.

Main Shop.—The main shop consists of a central aisle 50 ft. wide and 360 ft. long, two bays about 50 ft. wide each, one on either side, and a 75 x 95 ft. ell. The main aisle is known as the boiler shop, the north bay as the light-iron shop, while the south bay is devoted to plate and rivet storage, the machine shop, riveting towers, blacksmith shop, engine and boiler rooms. A pattern shop and pattern storage racks occupy the ell. The blacksmith shop, engine and boiler rooms are separated by partitions from the rest of the building. Outside the machine shop is a storage yard for castings, and at the east end of the blacksmith shop is a 25 x 56-ft. shed for the storage of tubes, with a 25 x 80-ft. tube shed opposite, adjoining the railroad track. Between the two spurs of the side track is a 20-ton pneumatic yard derrick with a 50-ft. boom. This section of the yard is used either for the storage of finished or raw material. In the eastern portion of the yard a wooden stable, 30 ft. by 40 ft. in plan, is being erected for the company's service.



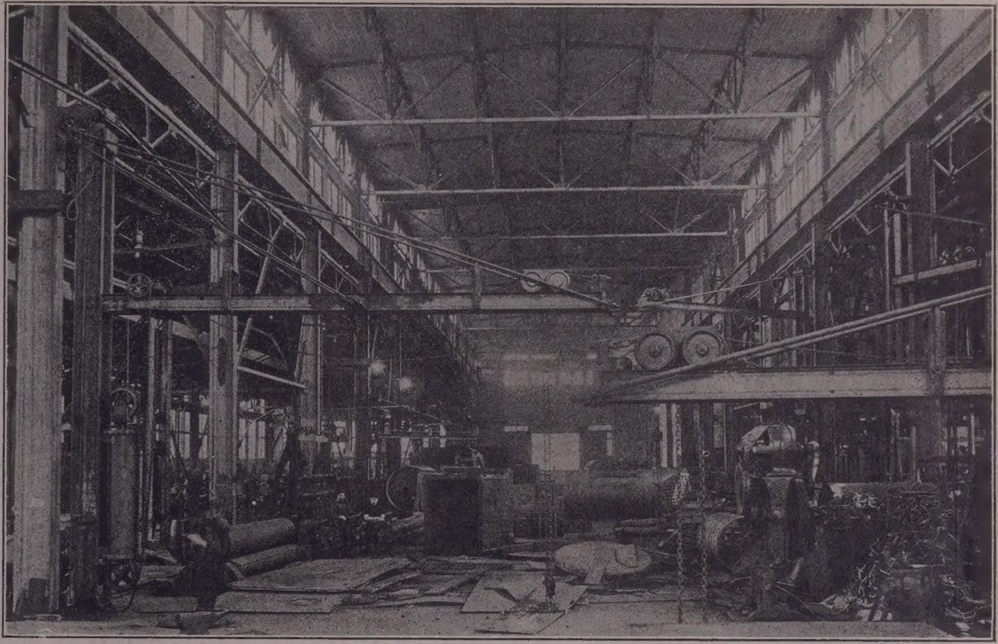
General Plan of the Shops of the Robb-Mumford Boiler Co.

All the steel in the shops was of Manufacturers' Standard railroad bridge grade. Lehigh Portland cement was used in making the concrete for the foundations and side walls. The wind loads were figured at from 20 to 30 lb. per square foot. The steel work was figured for 15,000 lb. per square inch on net sections in tension and 12,000 lb. reduced by Rankin's formula, in compression. The combined stresses from wind and vertical loads were taken at 20,000 lb. per square inch. No anchor bolts were used in the column footings except in the cases of the four outside columns at the easterly end of the building. Trussed purlins are used throughout, with braces supporting the bottom chords of all roof trusses. The whole structure is thoroughly braced in every direction, and is remarkably rigid. It was necessary during erection to jack up one of the columns a few inches, and it was found in doing so, that the adjacent columns were raised also.

The shop building was designed by Mr. E. E. Pettee, of Boston, consulting engineer, and the office building by Mr. S. D. Hayden, of Newtonville. The latter building was erected by Robertson & Simpson, of Auburndale, Mass. The shop walls, roofs and doors were erected by the Eastern Expanded Metal Co., of Boston, the steel framing being put in place by H. P. Converse & Co., of Boston. The excavation work, floor laying and foundation work were handled by Mr. G. H. Caughey, of Waltham, Mass. The tar and gravel for the roof was furnished by Warren Bros. Co., of Boston. E. Van Norden & Sons, of Boston, furnished the galvanized iron work, gutters and skylights, and Mr. H. L. Sawyer, of South Framingham installed the plumbing.

Material Handling Equipment.—Raw material arriving at the plant via the southerly spur track is disposed of as follows: Boiler plates are carried on the cars to the plate-storage division at the west end of the plant, and transferred to the racks shown in an accompanying illustration by a 5-ton electric traveling crane which serves the storage department. In the right foreground of this illustration is a rivet bin divided into eight compartments for the storage of standard sizes of rivets. Rivets are brought into the storage department on the cars, checked by the stock keeper, whose office is at the entrance of the ell and transferred by the traveling crane to the appropriate bin, via an overhead platform. At the bottom of the rivet bin is located a row of sliding doors, each one of which when raised admits the desired size of rivet to the operator.

Castings and all parts which are to be machined, such as heads, doors, nozzles, manhole frames and supporting lugs, are dumped from the cars, or from the delivering wagon into the yard outside the machine shop. A set of platform scales of 10 tons capacity is installed in the roadway between the office and the shops to facilitate the checking of castings on arrival. Bar iron and angle iron are stored in a rack just outside the blacksmith shop. All material is carefully recorded by the storekeeper on its arrival at the plant, and the stock room is designed to accommodate a large variety of equipment in a minimum amount of space. Overhead platforms and racks are built in a double tier with a floor between. The tubes are stored at the east end of the building to avoid carrying them through the shops, one of the last operations in the construction of a boiler being the insertion of the tubes.



Boiler Shop.

Plate Racks and 5-ton Electric Crane in Stock Department.

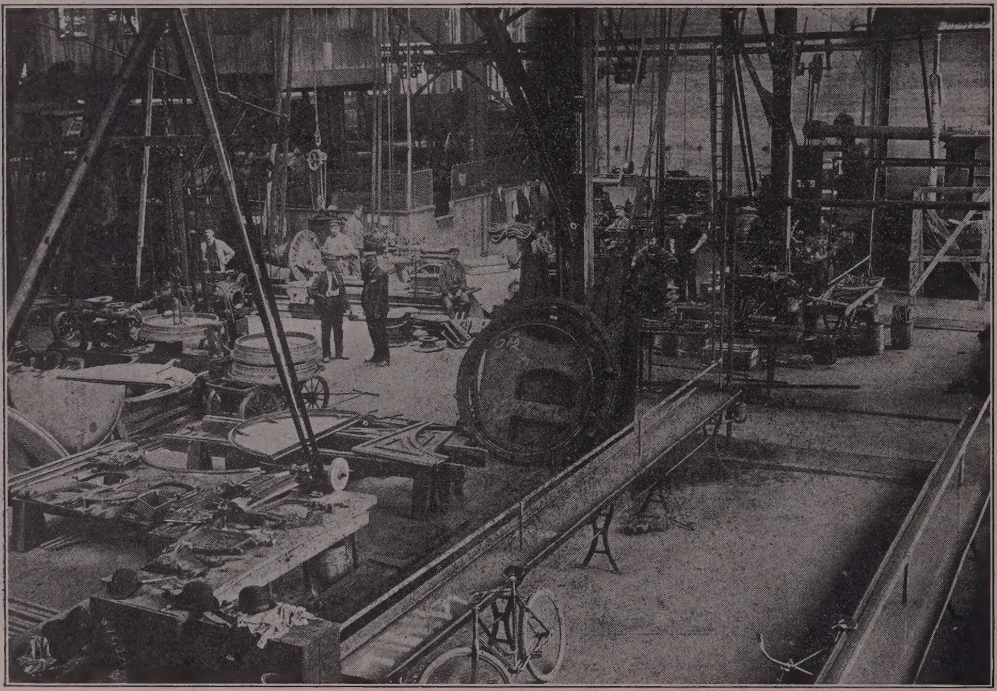
From the plate-storage racks the required plates are taken by the 5-ton crane previously mentioned, and delivered to one or more 5-ton pneumatic hoists at the west end of the boiler shop. This section is called the laying-out department, and here the stock is marked and prick-punched for the future machine-tool work which it is to receive. As will be observed by referring to the general plan of the works, there are 18 pneumatic jib cranes in the plant, in addition to several horizontal traveling cranes, so that every square foot of the floor is covered. The transportation facilities in all directions are especially convenient. The main aisle of the boiler shop is served by a 25-ton electric crane of 50-ft. span. From the floor to the top of the crane is 35 ft. Sufficient head room was allowed to enable any piece of work in the shops to be moved over any other piece of work on the floor. The main crane is equipped with a 5-ton auxiliary hoist. The main hoist is driven by a 35-h.-p. motor. All the electric cranes in the plant were supplied by the Northern Engineering Works, of Detroit, Mich. The radial jib cranes were made by the Robb-Mumford Co.

Shop Equipment and Processes.—After being laid out, the plates pass to the punchers, where the rivet holes are cut. The holes are punched below size and are later drilled out in assembly. The machine tools in the plant are all driven by 220-volt Crocker-Wheeler direct-current motors. The larger tools are connected to individual motors. In the boiler department are installed one Long and Allstater 54-in. punch, with a capability of punching a 1¼-in. hole in a 1¼-in. plate, or a 4 x 6-in. hand hole in a ⅝-in. plate, driven through a Reynolds silent chain by a 10-h.-p. motor; one flange punch for a maximum hole of 1¼-in. in a 1-in. plate and a horizontal punch with a 24-in. gap built to punch a 1-in. hole in a ¾-in. plate, the two being belt-driven by a 10-h.-p. motor; one Whitcomb splitting shear for ½-in. plates, chain-driven by a 10-h.-p. motor; one Lenox bevel shear, capacity ¾-in. plate, chain-driven by a 10-h.-p. motor; one Swampscott plate planer for beveling edges, which takes 18 ft. of stock at one setting and is driven by a 10-h.-p. reversible motor; and a Long and Allstater automatic punching, shearing and beveling machine, which has a capacity of two ¾-in. holes in a 5/16-in. plate and is belt-driven by a 10-h.-p. motor. From the punches the stock passes to the beveling machines where the edges are trimmed and beveled and thence to the bending rolls.

The bending rolls are installed on the north side of the boiler shop center aisle, and they deliver the rolled plates into a convenient position for handling by the main traveling crane. All material passes through the shop without doubling on its course. The largest bending roll is a 16-ft. Hilles and Jones machine having a top roll 22 in. in diameter, with two 15-in. bottom rolls. It will handle a plate 16 ft. wide and 1 in. thick, or one 10 ft. wide and 1¼ in. thick. The rolls are driven by a 40-h.-p. compound-wound motor, while a 15-h.-p. motor is provided for raising and lowering the top roll. There is also installed a set of 10-ft. horizontal bending rolls operated by a 35-h.-p. motor. The pneumatic jib cranes are all equipped with 25-ft. booms, roller, swing and traverse bearings, and ball thrust bearings.

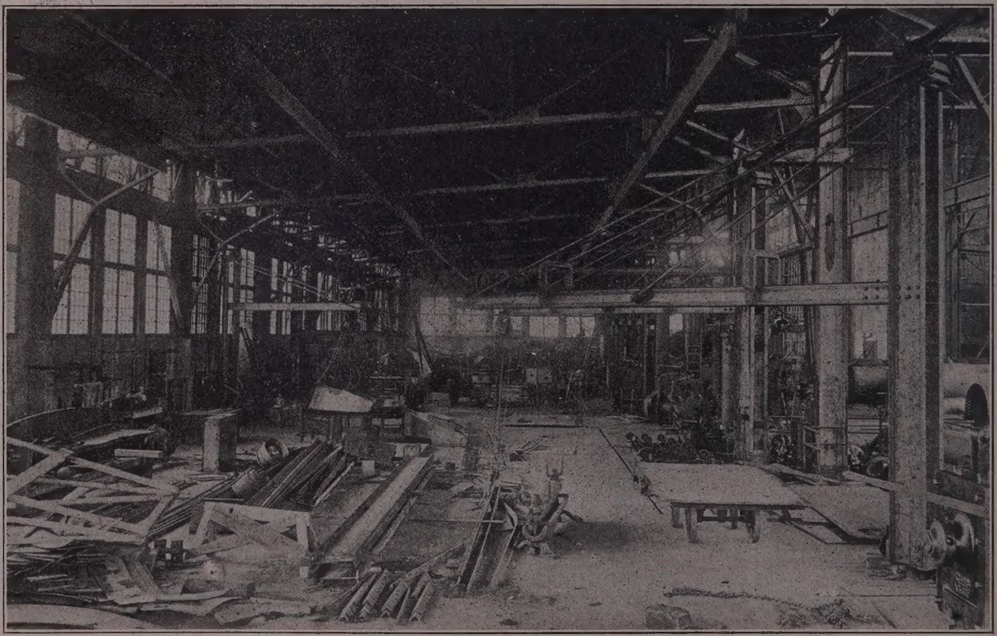
The plates are partially assembled after being rolled and are then drilled in place by one of three 15-ft. swing-boom drills, each of which is driven by a 5-h.-p. motor. These drills are installed in the north side of the center aisle, and are adjustable in height for drilling and reaming holes in the boiler shells. Directly beneath the drills is a track of 34-in. gauge, 90 ft. in length, running parallel to the center aisle. On this track are three specially designed cars of 12 tons capacity each and equipped with cross rolls for revolving the shells. When a shell is placed on these cars it can readily be brought in the proper position beneath the boom drill and revolved as the work of drilling progresses. Before the boiler is riveted, the nozzles, manhole frames and supporting lugs are added. The fronts, doors and rings are left for the final assembly.

The riveting towers are the next point to which the work is sent. The present installation for this work consists of two Bement-Miles hydraulic riveting machines of about 100 tons capacity each, with 10½ and 8½-ft. gaps, respectively. Sections 36 ft. in length can be handled in this division of the shop. The riveting towers are served by two electric traveling cranes of 15 and 20 tons capacity, respectively, the cranes being controlled from the riveting platform. These cranes each have a 50-ft. power hoist, with hand bridge and trolley travel. The crane motors are 35 and 25-h.-p. machines. The riveting towers are 24 ft. wide and 50 ft. in height, from the floor to the top of the crane rails. The riveting towers are served by four narrow-gauge tracks, two for each tower, in order to facilitate the ingress and exit of the boiler shells. Oil forges burning crude oil are employed for heating rivets, braces, etc. The riveting, which cannot be done at the towers on account of the position of the work, is done by pneumatic riveters on the shop floor. Caulking is also done by pneumatic tools. Compressed air is available at 100 lb. pressure at all the columns of the shop and at any other point where its use is frequent. The final assembly succeeds the caulking process, and after the tubes have been put in, the boiler is carried by the main crane to the testing department, which is a 30 x 50-ft. bay near the east end of the shop, with a floor drained into concrete troughs to carry off surplus water. It is connected with the boiler room of the plant by an underground conduit containing steam and water piping for steam and hydraulic tests. From the testing department the boilers are carried by the crane to the cars for shipment.


Machine Shop.

The machine shop equipment is all driven in group by a 20-h.-p. motor. It consists of two 54-in. radial drills, one at each end of a 10 x 14 x 8-ft. pit with a removable flow for special work; a 24-in. turret lathe, with a hollow spindle 4½ in. in diameter for cutting tubes and piping; two head drills for drilling tube holes; a special speed lathe for hinges and frames; a 36-in. drill, bolt cutter, Curtis pipe machine of 8 in. in capacity; a Knowlton boring and turning mill, with a capacity for pieces 9 ft. in diameter, for turning smoke heads, beveling the edges of boiler heads, etc.; bolt cutters, grinders, engine lathes, planers and a 36-in. blower for the blacksmith shop, which is supplied through a 10-in. galvanized-iron pipe. Part of the machine shop is given up to a tool room and above this is located a shop office for the superintendent, from which a good general view of the shop's interior can be had. Very little bench work is done in the plant.

All stock ⅛ in. or less in thickness is handled in the light-iron department after being laid out. This department occupies practically the entire north bay of the building. It contains a Whitcomb splitting shear for ¼-in. plate; three lever punches for ⅛ to ¾-in. holes in ⅛ to ½-in. plates, a 4½-ft. bending and straightening roll; a 6½-ft. bending roll driven by a 10-h.-p. motor; a punch for small flanges; and straightening block. All the tools except the large bending roll are driven by line shafting which is run by a 10-h.-p. motor suspended from the ceiling. Several of the large machines mentioned in the boiler shop description are readily accessible for the light-iron department.


Light Iron Department.

The blacksmith shop is equipped with two 5-ton radial jib cranes, two 5-ft. flange fire forges and a 9-in. flange forge, three small forges, two oil forges for heating brace rods and angle irons, a large double forge and a 350-lb. Bement-Miles steam hammer. A large rack for the storage of swedges occupies the west wall. A Dallett drill of the double-headed type for solid work has been installed and will be put in operation when required.

The pattern shop contains one trimmer, two trimming lathes, a jig saw, two circular saws, one band saw and a buzz planer, all group driven by a 20-h.-p. motor.

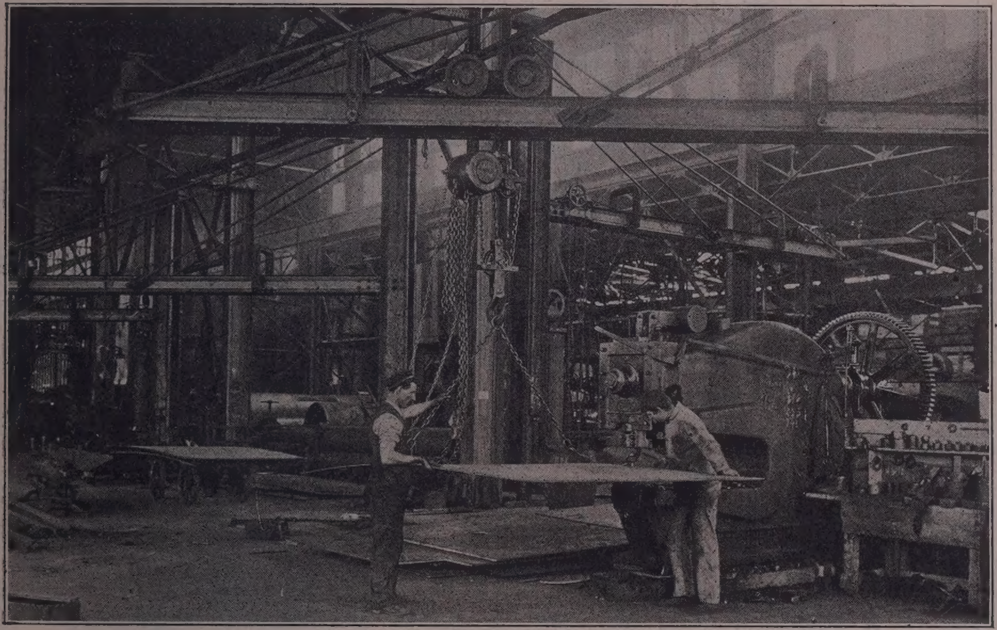
Power Plant.—The power plant occupies about 47 x 60 ft. in plan in the south bay of the shop. The boiler room contains two Robb-Mumford internally fired boilers, rated at 150 and 125 h.-p., respectively, and operating at 125 lb. pressure; a duplex feed pump for boiler supply, duplex pump for boiler filling and a single high-pressure pump for testing. The smoke flue and stack were built by the Robb-Mumford Co.; the stack is of sheet steel 54 in. in diameter and 80 ft. high. The engine room houses a 14 x 16-in. single automatic Ames engine, which is the main source of power for the different machines. It is direct connected to a 100-kw. 220-volt General Electric generator. The distributing circuits are controlled from a 5-panel switchboard mounted on a gallery at the west end of the engine room. The engine room also contains a feed-water heater and an Ingersoll-Sergeant air compressor, with compound steam and compound air cylinders and a capacity of 1,200 cu. ft. of air per minute, besides a Knowles steam-driven compressor of 200 ft. per minute capacity. The shops are heated by the Sturtevant blower system, which is installed to drive warm air through underground concrete ducts beneath the floor to risers located at suitable points along the shop walls, whence it is discharged into the room about 8 ft. above the floor. The fan engine and heating coils are located just outside the engine room in the machine shop section. The shop is lighted by 50 enclosed arc lamps and about one hundred 16-candle-power incandescent lamps, the wiring being of the open type. The office is lighted by the Boston Edison Co. with 110-volt alternating current.

The office, which fronts on Waverly St., and is isolated from the workshops, is designed with special reference to the accommodation of the elaborate stock and cost systems used by the company. The lower flat contains offices for the manager, general superintendent, accountant and a general office for the purchasing and stock department. The upper flat is devoted to the engineering department and draftsmen and includes a convenient blue-print room. All departments of the office and shop are connected by intercommunicating telephones.

The plant, which is now practically completed, has a capacity equivalent to about six hundred 72-in. boilers per year in addition to light-plate work and other products, when running 54 hours per week.

The primary object of the company is to manufacture the special line of internally fired boilers of the Robb-Mumford type for stationary, marine and portable purposes, but the production will include the standard return tubular, vertical and locomotive types and a line of water-tube boilers.

The officers of the Robb-Mumford Boiler Co. are: President, Mr. D. W. Robb, of Amherst, N. S.; managing director of the Robb Engineering Co.; secretary and treasurer, Mr. G. W. Cole, of Amherst, N. S.; general manager, Mr. Frederic H. Keyes; and superintendent, Mr. J. J. Wilde. The directors, in addition to the president, are: Messrs. R. C. Harris, president of the Nova Scotia Steel & Coal Co.; W. B. Ross, president of the Trinidad Electric Co.; W. M. Aitken, vice-president of the Commercial Trust Co., and J. A. Mumford, consulting engineer, New York.



Punching, Rolling and Beveling Machines.

Extruded Metal is a form of structural material in brass and bronze which is coming into extensive use in this country for architectural finish, structural and industrial purposes. The process of manufacture involves forcing the metal, heated to the temperature of plastic consistency, through accurately shaped dies by heavy hydraulic pressure, in a manner similar to that of forming lead pipe. The brass or bronze is heated in billets, which are placed in a forcing cylinder or container, with the die at the front end and the forcing plate at the rear, the plastic metal being forced through the die and issuing from it in a long bar of cross section corresponding to the opening of the die. Very high pressures are used, often reaching 60,000 lb. per square inch, which results in greatly increasing the density of the metal and rendering it perfectly homogeneous and free from the defects common to castings. The bars also have greater strength and tenacity than those made by the usual process of rolling or other methods of working.

The Disposal of the Sewage of Paterson, N. J.—II.

By Allen Hazen.

Trunk Sewer Project.—The trunk sewer project for cleaning the Passaic Valley was proposed by the Passaic Valley Sewerage Commission in 1897, of which Mr. Charles E. A. Jacobsen was chief engineer, and Mr. A. Fteley was consulting engineer. At that time it was proposed to discharge the sewage into Newark Bay, and ultimately, when it became necessary after a generation or more, to take it across Staten Island into Lower New York Bay.

Discharge Into New York Bay.—In 1902, after further consideration and acting upon the advice of Messrs. Rudolph Hering. J. J. R. Croes and William M. Brown, consulting engineers, the State Sewerage Commission recommended a project following the main line in the earlier one, but differing in important particulars.

The most important difference was in the point of discharge. This was changed to a point near the middle of the Upper Bay about half a mile north of Robbins Reef Light.

In 1903 the Passaic Valley District Sewerage Commission, of which Mr. Rudolph Hering was chief engineer, made a further report in which substantially the same project was adopted, although changes were made in the alignment and other details, and the capacity of the sewers was somewhat increased over those previously recommended. Later the same commission made a supplementary report on the proposed outlet, with professional opinions favorable to it by a number of eminent engineers.

All the above mentioned reports are printed documents. For the purpose of this study I have adopted Mr. Hering's plan as being the best plan for a trunk sewer thus far proposed.

High and Low Level Sewers.—The trunk sewer now proposed is intended to drain the whole district. It will serve the whole district for a certain period of years. After that, additional outlet capacity will be required. It seems clear that this will not be provided by a second sewer parallel with the one first built. It will be much better to build a second sewer at a higher level, capable of taking the sewage from the higher and larger portion of the district to the outlet by gravity. Such a sewer is clearly feasible. The high level sewer would first remove the sewage from the district tributary to the lower or southern part of the trunk sewer; that is, from the higher parts of Newark, from the Oranges, Montclair, Bloomfield, etc., but it could be extended to take also a large part of the sewage from the upper or northern part of the district. If that is accomplished the trunk sewer first built will drain only the lower part of Newark and a narrow strip along the Passaic River reaching up approximately as far as Passaic and then broadening out to include a considerable territory not sufficiently elevated to be reached by the high level sewer. This development seems reasonably certain and should be contemplated and the design of the trunk sewer arranged somewhat with reference to it. Certain other matters should also be taken into account which would modify somewhat the carrying capacity of the sewer, but would not change materially the total cost of the project.

Point of Discharge.—Mr. Hering, following the Hering-Croes-Brown project, recommends the discharge of sewage into New York Harbor. From the standpoint of New Jersey this seems to be clearly the most advantageous point of discharge. Many people in New York have objected to such discharge, and the objection led to the appointment of a Commission on the Pollution of New York Bay, and of a formal report on the subject in 1905, and quite recently to further action in the same direction. It is questioned whether or not New York has the legal right to stop the discharge of sewage at the point and in the way proposed. Different opinions have been expressed upon this point, and it seems that this is a matter which can only be finally settled in the courts if the necessity for a settlement should arise.

It may also be questioned whether, in case the court should hold that New Jersey had the legal right to do it, that State would wish to discharge the sewage in the way proposed, and whether it would be wise for it to do so, in spite of New York's protest.

It is clear, however, that in case New Jersey should abstain from using the harbor because of New York's objection to the additional pollution, either voluntarily or through constraint, it would only be fair for New York to make a corresponding effort to prevent sewage discharge on the New York side of the bay.

It must be admitted that New York is better off without the discharge of New Jersey sewage. The discharge of sewage will tend to pollute the bay locally. There will be an appearance of sewage for some distance around the proposed outlet, and this outlet is near the main channel up the harbor. There will be some odor, and grease from the sewage will smooth the waves and show its presence over a considerable area. To a certain extent these phenomena are disagreeable and objectionable, and if New York could stop them without damage to others, it is clearly for her interest to do so. New York is now putting practically all of her sewage into the harbor.

The New York Bay Pollution Commission lays great stress on the fact that this sewage is put in at a great many points separated from each other, and that no such large body of sewage is put in at one point as would be contributed by the Passaic Valley outlet. There may be a question as to how much weight should be given to this contention. The main facts are that New York is disposing of substantially all of her sewage by dilution in the water of the harbor, and that the water of the harbor is not seriously polluted by this discharge at the present time. The oyster industry perhaps suffers from it; but I believe that growing oysters in the harbor should be prohibited forthwith, and that without reference to the proposed discharge of New Jersey sewage.

New York Harbor is clearly capable of receiving the sewage of a population very much larger than that now tributary to it without becoming objectionably contaminated, but there is a limit to the amount which can be so discharged. If the city keeps on growing the limit will be sometime reached. If the New Jersey sewage is kept out of the harbor, then the limit will not be reached as soon, and New York's sewage can be discharged for a longer interval without producing offensive conditions.

New York would rather have the New Jersey sewage kept out of the harbor. But it may be questioned whether she has the legal or moral right to refuse to share the natural advantages of the harbor with her neighbor, who owns a considerable portion of its shores and would seem by right fully entitled to share in the advantages of the location.

Outlet in Kill von Kull.—A possible solution of this problem which deserves consideration is the use of an outlet in Kill von Kull or in Newark Bay, near the upper end of it, as shown on the accompanying map of New York Harbor and the proposed outlet. Following the New York Bay Pollution Commission report, but with some revision, the total population tributary to New York Harbor, including the Passaic Valley and all territory tributary to Newark Bay, in 1905 was 5,048,000. I compute that of this, 778,000 were tributary to Newark Bay directly, or 15.4 per cent. of the whole. I have included in this figure not only the whole of the Passaic sewerage district, but also the suburban part of the Hackensack Valley, Elizabeth, and the towns which might reasonably reach Newark Bay from that general direction.

The tidal volume (flood) flowing through Kill von Kull, according to the same authority, is 1,750 million cubic feet, while the total tidal volume (flood) flowing through the Narrows is 12,750 million cubic feet. The tidal flow through Kill von Kull therefore is 13.7 per cent. of the tidal flow through the Narrows, or substantially as much in proportion to the New Jersey sewage as the flow through the Narrows is in proportion to all the sewage.

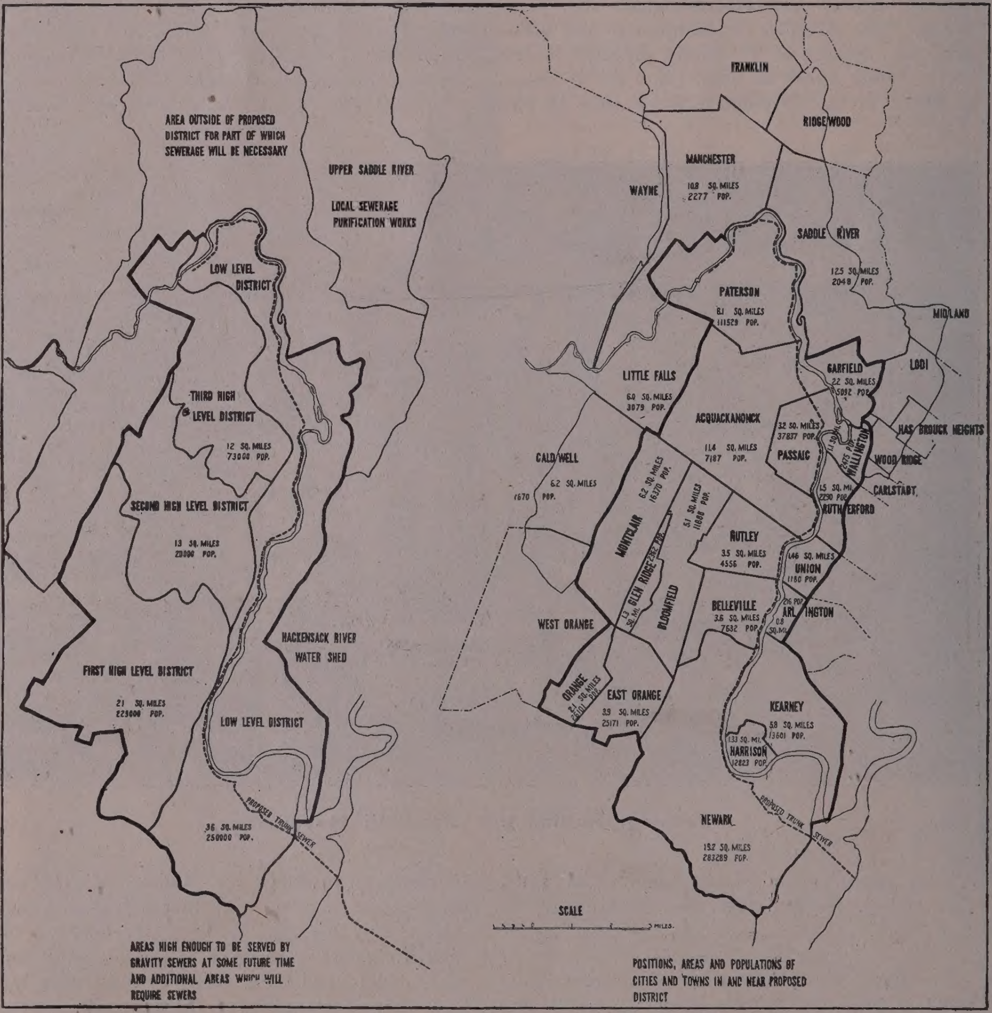
The ability to absorb and dispose of sewage depends somewhat upon other matters than the tidal flow, but in a general way the tidal flow is a good index of absorbing power, and we shall not be far wrong in assuming that the Kill von Kull is capable of disposing of as much sewage in proportion to its tidal flow as is New York Harbor in proportion to the flow through the Narrows; and on this basis the opportunity for sewage discharge into Kill von Kull for New Jersey is substantially as favorable as for the discharge of all the sewage of Greater New York into New York Bay, including Kill von Kull.

In one respect Kill von Kull is particularly favorable as a point of discharge. The tidal currents are very strong. The advantage of strong currents is obvious from an inspection of the outlets in Boston Harbor, where the sewage is more rapidly and completely dispersed in the stronger currents. This circumstance may, therefore, offset the fact that the outlet to Kill von Kull would be nearer inhabited shores than the outlet in New York Bay north of Robins Reef Light.

From a point in the proposed trunk sewer line in Newark where the lines might diverge, the distance to an outlet in Kill von Kull is about 11 per cent. less than the distance to the proposed New York Bay outlet. The general form of construction in the two directions would be similar and it seems that there would be no very great difference in the cost of carrying the sewage one way or the other. If there is any difference, probably it would be cheaper to go to the Kill von Kull Outlet.

Adequacy of the Kill von Kull Outlet.—It seems fair to count on the use of an outlet for the New Jersey sewage in the Kill von Kull for at least a generation, and in all probability for a much longer time. This matter is speculative when we try to get far into the future. We do not know how rapidly the cities will grow or what standards of cleanliness and nuisance a future generation may have, nor do we know what the polluting power of the sewage of the future will be, for it is quite possible that, owing to changed habits, food and manufacturing conditions, it may be materially different from that of the present day. Furthermore, our information as to the present ability of such tidal flows as those in Kill von Kull to absorb sewage is of a very inadequate character and does not allow a close estimate of sewage absorbing ability even at the present time.

The length of time that such an outlet could be used, therefore, either in Kill von Kull or New York Harbor, is a matter which will be determined by experience as the years go by, and is incapable of being calculated at the present time. It is clear that either outlet is sufficient for the present and for a long series of years, and we may therefore base our estimates on the use of one of them, and we may assume that the cost will be about the same whichever is used.



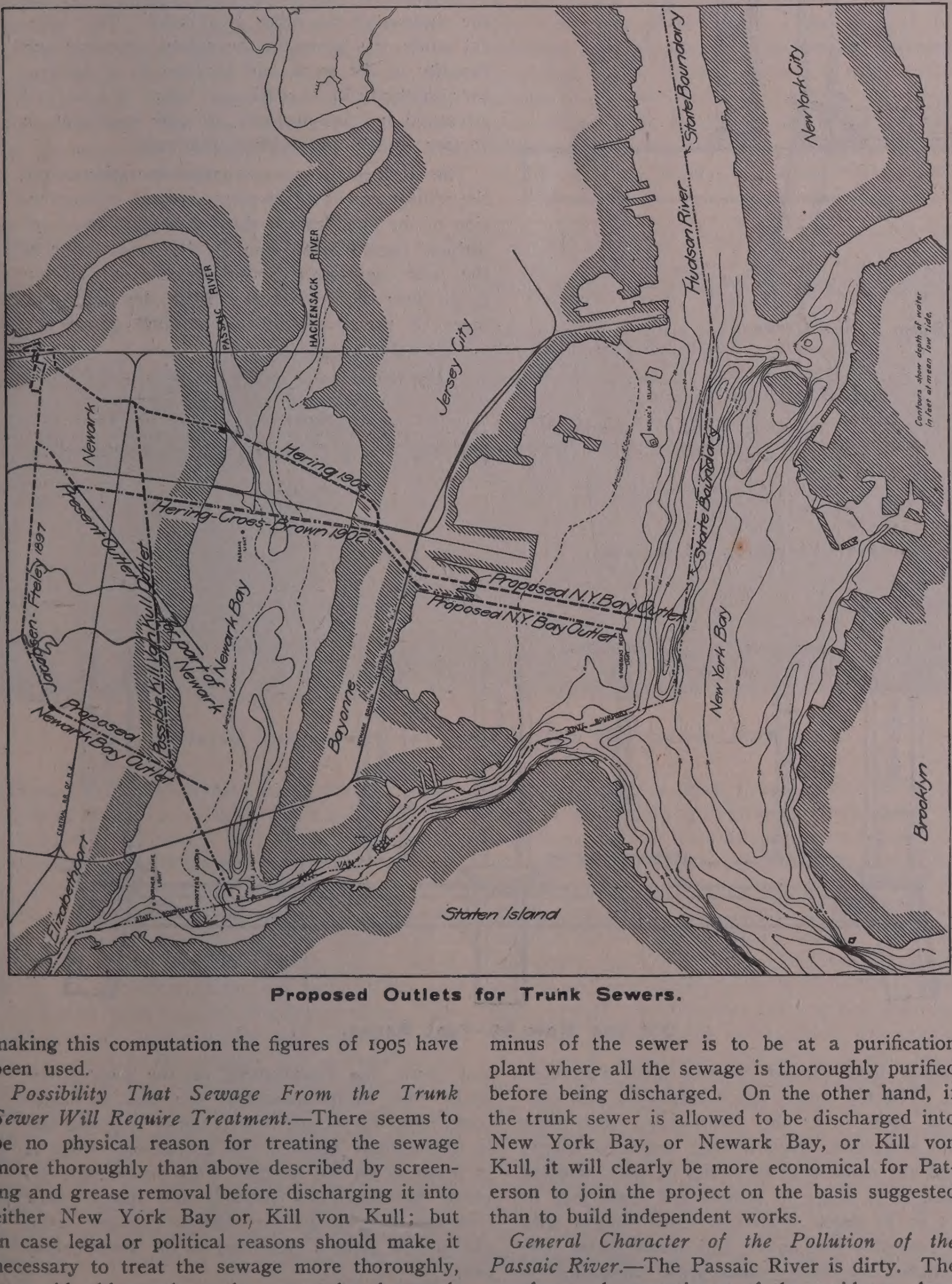
Areas to be Served by Proposed Trunk Sewer.

Preparatory Treatment for Tidal Discharge.—Whatever outlet for tidal discharge is adopted there are some things that can and should be done to improve the situation. The objectionable appearance of the sewage largely comes from two matters, first, from the floating oil and grease; and second, from the coarser suspended and floating matters. In some sewer outlets now in use these materials are separated in part, but it is clearly possible to carry the separation much further without undue expense. Tanks with scum boards should be provided to allow the sewage to come to rest, and be freed from as large an amount as possible of the floating oil and grease; the screening should be done through closer screens with automatic cleaning devices so that no considerable floating particles will be observed in the discharged sewage. The prevention of the appearance of sewage will substantially reduce the objection to its discharge, although it will not materially change the conditions as to odor and the general pollution of the Bay.

Power of the Harbor to Absorb Sewage.—In this connection it may be stated that there is no danger of over-taxing the oxydizing power of the Bay and Harbor water at the present time. The amount of sewage now discharged is so small as to use only a fraction of the absorbing power of the salt water, which is brought in with every flood tide. Approximate computations indicate that one-fourth of the water coming into the Harbor at each flood tide is sea-water which has not been in the Harbor before, and it is this new sea-water which principally gives the Harbor its enormous power of absorbing sewage. The fresh water which enters the harbor through various rivers is a minor and almost unimportant element in the problem. At times of flood in these rivers fresh water, to a large extent, takes the place of the salt water and drives the salt water out, and for the time being the fresh water takes the place of the salt water in absorbing sewage. But this is an unusual condition; if the fresh water did not enter at this time, the salt water would do so, and it is the salt water on which dependence is placed, and which does the bulk of the work, specially in dry weather when the river flows are low and when the sewage is most likely to be offensive.

The salt water is cooler than the fresh water, and for this reason has a greater power of absorbing, oxydizing and destroying the sewage with which it mixes, and the processes which give rise to offense are less likely to take place at a lower temperature than at the high temperatures which are reached in fresh water in midsummer.

Cost of the Trunk Sewer.—The cost of constructing the trunk sewer is estimated at $10,600,000. To this must be added, however, $2,700,000 for additional outlets required in the not distant future. Probably a slight saving in total expense could be made by using the Kill von Kull outlet instead of the New York Bay outlet. The cost of inspecting, cleaning and administering and pumping the sewage is estimated at 18 cents per capita annually. It is assumed that Paterson's share of the cost is to be determined by the ratio of the valuation of property in that city to the valuation of the district. In making this computation the figures of 1905 have been used.



Proposed Outlets for Trunk Sewers.

Possibility That Sewage From the Trunk Sewer Will Require Treatment.—There seems to be no physical reason for treating the sewage more thoroughly than above described by screening and grease removal before discharging it into either New York Bay or Kill von Kull; but in case legal or political reasons should make it necessary to treat the sewage more thoroughly, it would add greatly to the cost under the trunk sewer scheme. A less thorough purification of sewage might suffice if it was to be discharged into Newark Bay than would be required for sewage to be discharged above Passaic; but on the other hand, the site for works below Newark seems to be very much less favorable than the one below Paterson. Below Newark apparently it would be necessary to build on the meadows. The perfectly level surfaces of these meadows do not lend themselves readily to the construction of settling tanks at an elevation to supply sprinkling filters by gravity. Apparently it would be necessary either to elevate the settling tanks at great expense or else to pump the sewage a second time in passing from them to the filters.

The purification of the sewage from the district by any process now known, sufficiently to give a reasonably pure effluent, including capital charges on the works constructed on the meadows, would hardly cost less than 50 cents per capita annually. Adding this to the 95 cents per capita estimated for the crude discharge makes the total cost of construction and operation of the sewage purification works $1.45. This is more than the cost to Paterson of treating her sewage separately.

Putting it in another way, Paterson cannot afford to join a trunk sewer project if the terminus of the sewer is to be at a purification plant where all the sewage is thoroughly purified before being discharged. On the other hand, if the trunk sewer is allowed to be discharged into New York Bay, or Newark Bay, or Kill von Kull, it will clearly be more economical for Paterson to join the project on the basis suggested than to build independent works.

General Character of the Pollution of the Passaic River.—The Passaic River is dirty. The comfort and convenience of the residents along its banks require that it should be cleaned. Cleaning it is a matter of general cleanliness and comfort rather than of public health. The odors which arise from decomposing sewage do not cause typhoid fever or small-pox or scarlet fever or any other contagious disease. They may, and often do, reduce the comfort and happiness, and consequently in a sense the health of the people subject to them; but it cannot be maintained that they cause serious illness. If it were a matter of public health there are other reforms which could be carried out at less cost, which would do far more good.

The present condition of the river is such that it is not pleasant to bathe in it, or to use it for boating purposes, or to live too near its banks; and the feeling that it is unhealthful, even though not supported by scientific evidence, weighs with those who have to do with it. These conditions reduce the availability and value of the shore of the river for many purposes, and for these reasons it is worth while to clean the river, without reference to public health.

Points of Pollution.—The Passaic River is polluted by the discharge of sewage and manufacturing wastes and other refuse, all the way from Little Falls to Newark Bay; but there are two points where the pollution is so much greater than elsewhere that they require special mention. These are Dundee Lake, which is polluted by the sewage and wastes of Paterson so as to be extremely dirty; and the river opposite and below the center of Newark, which is polluted by similar discharges from Newark and from towns which discharge their sewage to the river through Newark. In these two general localities the condition of the river is far worse than at many intermediate points. Possibly the river below Passaic might be added as a third point of special pollution.

TABLE I.

Financial Comparison, Bringing Together the Most Important Financial Data.

	Total cost for the trunk sewer project.	Paterson's proportion of trunk sewer cost on basis of valuations of 1905.	Corresponding cost for separate works.
Total cost of works suitable for a population 2.25 times as great as that of the census of 1905.	$13,323,000	$2,292,000	$3,028,000
Cost of those parts to be constructed at once	10,623,000	1,827,000	2,428,000
Capital charges on those parts at 5 per cent.	531,000	91,400	121,400
Cost of operation for population of 1910	153,000	29,670	61,920
Cost of storm water separation..	0	12,900	12,900
Total cost for 1910	684,000	133,970	196,220
Through a series of years the average capital invested per capita is	14.00	12.40	16.00
Interest and sinking fund charges on same at 5%	0.70	0.62	0.80
Pumping and administration ...	0.18	0.18	0.18
Purifying sewage	0	0	0.38
Screening and grease removal.	0.05	0.05	0
Storm water separation	0.00	0.10	0.10
Total annual per capita cost	0.93	0.95	1.38
Excess cost of separate disposal works.........			0.43
Equal to 45 per cent.			

The relative locations of the two cities are such that more of the people of Newark are near the river and suffer from a given pollution than is the case of Paterson.

At Belleville the water of the Passaic, in its raw state, was used for drinking purposes by Jersey City as recently as 1897, even though at that time in Dundee Lake and opposite Newark the river had become extremely offensive.

The condition at Dundee Lake must be attributed to the sewage and wastes of Paterson, and it is Paterson which principally suffers from these discharges. The discharges of Newark and the towns reaching the river through Newark are principally responsible for the conditions opposite Newark.

Paterson's sewage is a contributing cause to a slight extent to the condition at Newark, but it is only to a slight extent. The river at Newark would not be materially improved by stopping the discharges from Paterson; and if the lower discharges were removed, leaving only Paterson's there would not be the slightest nuisance in the river opposite Newark.

While the cleaning of the whole of the Passaic River is therefore one problem, and it is no doubt best to take it up all at one time and to specify the same date for cleaning all parts of the river, the problems are in reality very largely local ones, and both Paterson and Newark suffer principally from their own wastes.

Recommendations.—In view of all the facts and circumstances as I have found them, and upon the supposition that a full, just and lawful arrangement with the other municipalities upon the Passaic River is reached, acceptable to the Legislature and to the Governor, I believe that the interests of Paterson will be best served by joining with other municipalities in the construction of a trunk sewer to take the sewage from the entire district requiring sewage disposal facilities in the Lower Passaic Valley to a point of adequate sea water dilution, either in New York Bay or Newark Bay near the Kill von Kull. I believe that this arrangement will be substantially better for Paterson than the separate local purification of her sewage.

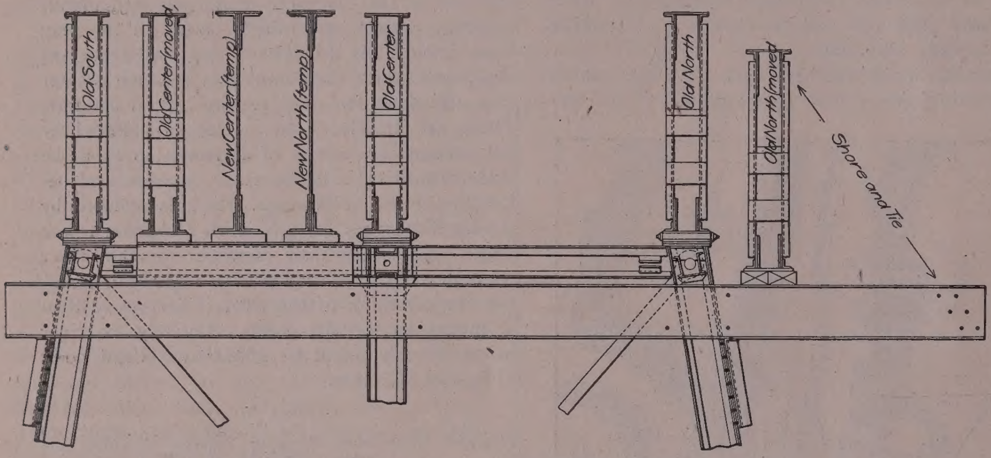
If, however, great obstacles to this arrangement should be found, or if it should be necessary to purify the sewage collected in such a trunk sewer before discharging it into salt water, then clearly it will be for Paterson's best interests to purify its own sewage near home; and the general plan outlined herewith and shown by the plans accompanying it would be the best one to adopt.

[The foregoing is a complete abstract of a report presented to an aldermanic committee of the city council of Paterson by Mr Hazen and covers all of the technical features of that report in detail.—Ed.]

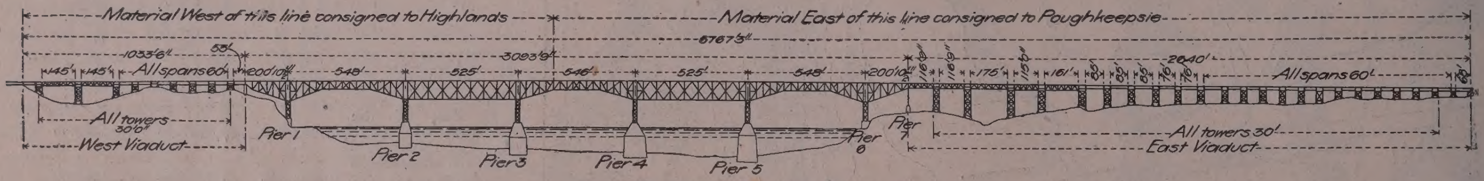
An Order for 80,000 Steel Ties for this year's delivery has recently been placed with the Carnegie Steel Co. by the Bessemer R. R. of the United States Steel Corporation. This number of ties is sufficient to lay 30 miles of track. The ties will be laid in continuous stretches instead of a number of short portions, as has been done by the various railroads that are experimenting with this type of tie.

Replacing Viaduct Girders in the Reconstruction of the Poughkeepsie Bridge.

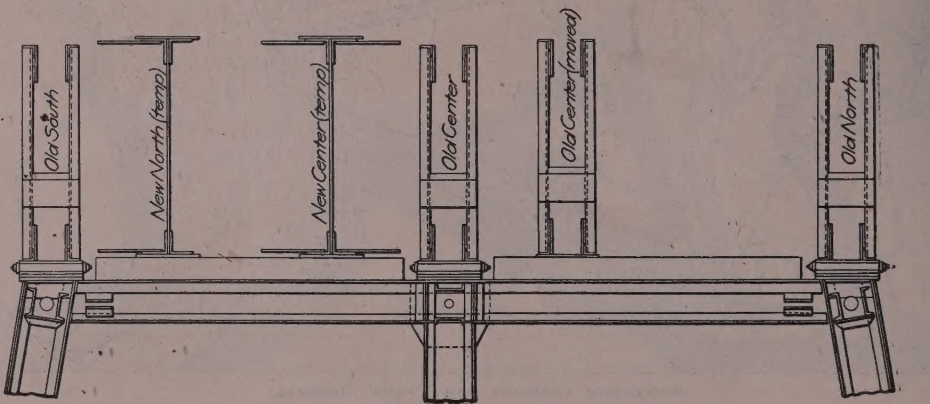
The double-track railroad bridge across the Hudson River, at Poughkeepsie, N. Y., was built about twenty years ago and was proportioned for trains weighing 3,000 lb. per linear foot headed by two coupled locomotives each having four 24,000-lb. axle loads. It is now being reinforced and reconstructed for service with 3,600-lb. train loads headed by two locomotives each having four 45,000-lb. axle loads. The bridge has a total length of 6,767¼ ft. and a maximum clearance of 163 ft. above high-water level. The substructure is of stone masonry which for the four river piers has deep foundation cribs filled with concrete. The five nearly equal cantilever and connecting spans over the river, have, with their anchor arm shore spans a total length of 3,093¾ ft. and are made with two lines of pin-connected trusses, 30 ft. apart on centers and from 37½ ft. to 75 ft. in depth, seated on steel towers with their pedestals just above high-water mark. The approaches are chiefly made with alternating 30 and 60-ft. plate-girder spans and seven pin-connected truss spans from 116 ft. to 175 ft. in length, which are supported on iron towers as shown in the general diagram. They are all made with three lines of trusses or girders, the center one being supported by transverse pin-connected Fink trusses in the tops of the transverse trestle bents.



Temporary Support for Long Span Plate Girders.



General Elevation of Bridge.



Old and New 60-Foot Spans.

The anchor piers will be reinforced by a large amount of new steel work and concrete. New columns and braces will be added to the trestle bents, the old trusses and girders in the viaducts will be replaced by new plate girders in the same planes up to 85 ft. spans, the approach trusses will be taken down, shipped to the bridge shops, reinforced, brought back and re-erected, and the main spans will be strengthened by the introduction of a third line of new trusses in the axis of the bridge. This work, which will require about 15,000 tons of new steel, and will cost about $1,500,000, was briefly described in The Engineering Record for Oct. 28, 1905.

The great height of the structure and the requirement that train service shall be maintained uninterrupted on it during the execution of the work made the problem a sufficiently difficult one. The danger and expense were greatly increased by the three-truss type of superstructure in the viaduct approaches in which the center trusses and girders are indispensable to the support of both tracks so that in order to replace one track the support of the other is affected. Very careful study was given to the safety, economy and rapidity of the work and resulted in a satisfactory solution, the execution of which is now well advanced and has probably no close precedent, in former bridge and viaduct renewals.

The work involves six separate operations, first, the reinforcement of the piers; second, reconstruction of the anchorages; third, construction of additional trestle bents; fourth, the construction of the new main-span center trusses and an entirely new floor system; fifth, the reinforcement of the spans in the viaduct approaches, and sixth, the replacement of the plate-girder spans. Of these operations the first is nearly completed, the second is well under way, the last is substantially finished and preliminary work is in progress on the fourth. This article will describe the ingenious methods and special plant used for effecting the very difficult exchange from old to new girders embraced in the sixth operation.

Two storage yards were established near the ends of the bridge on opposite sides of the river in which the material was arranged so that it was most easily accessible for the positions required in the structure. The train service was confined at first to the north track of the bridge and the south track was utilized principally for the movement of derrick cars which remained continually on the structure. The materials were handled by a locomotive and ordinary flat cars on the north track between regular trains and the north track was generally free from regular trains between 3:30 and 6 p. m., in which interval the final changes of track and girders were made.

In the old structure the 60 to 85-ft. girders were much deeper than the 30-ft. girders and were seated directly on the towers, with bearings considerably above the tower tops to receive the ends of the 30-ft. girders. A long girder could not, therefore, be handled independently, but necessitated the simultaneous support of the two adjacent 30-ft. girders thus making at every operation a 120 to 145-ft break in the continuity of the girder line. First, the wooden ties, continuous across the full width of the bridge floor were cut near the center line; the rails and ties were removed for the south track and the lateral and transverse bracing cut out between the old center girder and the old south girder. Second, one 30-ft. and one 60-ft. old girder in the south line were removed by two 25-ton derrick cars each having one 50-ft. and two 30-ft. booms; the other old 30-ft. girder adjacent to the 60-ft. girder being left in position with one end supported on blocking above the top of the tower. Third, the 30-ft. and 60-ft. new girders for the south line were delivered by flat cars, unloaded by the derrick cars and seated in their permanent positions on the towers. Fourth, the new 30 and 60-ft. girders for both the center and north lines were delivered on flat cars, unloaded and set by the derrick cars in temporary positions on the top of the transverse Fink trusses, south of the old center girder, the new center girder being placed as close as possible to it and the new north girder as close as possible to the new south girder. Fifth, the north or operating track was removed. Sixth, the old center girder was moved north and temporarily seated on the transverse truss. Seventh, the new center girder was put in its permanent place in the position just vacated by the old center girder. Eighth, the old center girder was moved to the opposite side of the new center girder and supported on the transverse truss in the south track. Ninth, the old north girder was moved south and seated on the transverse trusses. Tenth, the new north girder was changed from its position near the south girder to its permanent position on the caps of the north columns. Eleventh, the old north girder was moved to a position adjacent to the old center girder in the south track. Twelfth, lateral bracing ties and rails were placed for the north track, and traffic was resumed on it. Thirteenth, the old center and south girders were loaded on cars and removed on the north track, this usually concluding the day's work. The following morning operations were resumed, the fourteenth, the lateral ties and rails were put in place for the south track. Fifteenth, the derrick cars were moved ahead, completing the cycle, and the operations above described were repeated for the next two spans, and so on.

Building Mattress Revetments on the Mississippi River.

The replacement of the 30 and 60-ft. spans was accomplished by 30 men in nine hours when not interrupted by extra trains. The replacement of the girders in the 30-ft. spans was made in the same sequence and at the same time as above described. The work was expedited by an advance gang which cut the transverse bracing of the old superstructure and temporarily splice-bolted it so that no time was lost in its removal when the girders were changed. The field rivets of the new superstructure were not driven until a later date on account of the necessity of breaking the track between towers at every panel, an operation which would have disconnected the compressed air pipe and interrupted the operations every day.

For the renewals of the 76, 80 and 85-ft. spans, the two derrick cars were spaced 136, 140 and 145 ft. apart in the clear so as to clear also one long span and two short spans. The method of handling these spans was somewhat different from that of the shorter spans and necessitated temporary support of the ends of the old tower spans which were carried by the long intermediate spans. It was therefore necessary, first, to cut out the rivets in the cover plates of the transverse bent inclined posts and to bolt to the latter bracket plates having reinforced shelf angles to receive pairs of horizontal transverse I-beams 24 in. deep, which formed temporary girders across the tower and cantilevered beyond it about 9 ft. on the north side. Short lengths of 15-in. I-beams were set on their upper flanges between the south and center girders to form platforms to receive the old and new girders at the level of the column caps; second, the ties were cut and ties and rails removed for the south track; third, the girders of the 30-ft. spans were blocked up to take bearing on the temporary transverse I-beams; fourth, the transverse bracing was cut between the center and south girders; fifth, the derrick cars were put in position 145 ft. apart on the ends of the adjacent intermediate spans; sixth, the old south girders were removed and taken away on the north track; seventh, the new north girders were brought in and placed in permanent position; eighth, the new north and center girders were brought in and temporarily seated on the transverse beams adjacent to the center and south girders, respectively; ninth, all of the old tower girders at one end of the intermediate span were removed; tenth, the ties and rails of the north track and the transverse bracing between the north and center girders were removed; eleventh, the old north girder was moved north and seated on the cantilever projection of the transverse I-beams close to the trestle bent and securely braced by inclined struts and ties from its top flange to the end of the beam; twelfth, the old center girder was moved to a position between the new center girder and the new south girder; thirteenth, the new north and center girders were moved to their permanent positions and their bracing assembled; fourteenth, the corresponding changes were made for the girders in the 30-ft. span at the other end of the intermediate span; fifteenth, the north track was laid; sixteenth, the old north and center girders were loaded to cars on the north track and removed; seventeenth, the south track was placed, and eighteenth, the derrick cars were advanced to the next span and the same sequence of operations was repeated, care being always taken to prevent the passage of trains while the 30-ft. girders were supported on the transverse I-beams.

The changes to the viaduct superstructure will be completed, after the new girders are all in position, by supporting the center girders on new vertical columns in the transverse planes of the tower bents which will supersede the transverse trusses. The top chords will be retained and will continue to serve as transverse struts of the lateral system while the vertical posts will be removed. The new columns are made with pairs of built-up channels, about 15 in. apart, back to back, which are received separately from the shop and are assembled on opposite sides of the vertical posts in the old trusses so as to clear them. They are latticed together in the field and receive the loads from the center girders before the old trusses are disconnected.

The calendar of operations up to date is as follows: Work was commenced in February, 1906, on the excavation at the shore piers one and four. Concreting for them and the construction of the viaduct pedestals was commenced in May. Cutting of the llaterals, reinforcement of the subvertical posts in the anchor arms of the main spans and the replacement of the viaduct girders was commenced May 25. The changes on pier six were completed May 20. The falsework for the east anchor arm was commenced June 19. The changes on pier one were completed June 25. The renewal of the girders in the east approach viaduct were completed July 1. The renewal of the west approach viaduct was commenced Aug. 1, and was completed in about two weeks. The pedestals for the east approach viaduct were completed July 1.

The construction here described is being done by the New York, New Haven & Hartford R. R. Co., Mr. F. S. Curtis, second vice-president, and Mr. E. H. McHenry, fourth vice-president. Mr. Mace Moulton is the consulting engineer, and the American Bridge Co. is the contractor for both masonry and steel work. The field construction is being done by Mr. S. P. Mitchell.

AN OZONE PLANT FOR WATER PURIFICATION has recently been installed at Saint-Maur, near Paris. The water treated is taken from the river Marne and is usually clarified by deposition or filtering through sand, and is then driven through a sterilizer at a uniform rate of flow, in which air, after being impregnated with ozone, is brought into contact with it. The ozone is generated on the system of Frise, the electrified air being cooled to below 25 per cent., which is the temperature most favorable for ozone production. The electric current supply for the ozone production is furnished by an alternating current generator and transformers designed to deliver 40,000 volts alternating, which is driven by the 45-h.-p. engine that also operates the 33,000-gal. centrifugal pump handling the water. The results of the process have been very satisfactory, the amount of energy consumed in handling 22,000 gal. of water per hour amounting to 4.8 h.-p.

Mattress Revetments On the Mississippi River.

By Harry N. Howe.

A large portion of the immense sums of money spent by the national Government in the improvement and maintenance of the channel of the Mississippi River and its tributaries has been devoted to the protection of the banks of those streams from the errosive action of the current. The most obvious method of securing the desired protection is by covering the exposed bank with some non-erodible material, or construction, that must be quite impervious to dangerous currents, fairly durable and of sufficient strength to withstand the strains of manufacture and placing on the site. The construction that has been found to be best adapted to these requirements by the 25 years of experience of the Government engineers in such work is a fascine mattress of willow brush which is generally loaded with broken stone to hold it in place.

When a bank is to be protected it is first cleared of timber and debris for a width on the river side of slightly more than three times its height. A pile abutment is then built at one end of the site and to this abutment are moored a number of barges. Other barges on which the mattress is made are firmly lashed together end to end, swung out into the stream across the site the mattress is to occupy, and moored to the pile abutment by diagonal lines to anchorages along the bank. The greater part of the mattresses consists of straight willow brush cut from the banks of the river. This brush is loaded on barges and floated to the site of the work, where these barges are swung into position below the barges on which the mattress is woven, as shown in the accompanying illustration.

In constructing a mattress, a head consisting of a bundle of hard-wood poles, sycamore or ash, in sizes up to 8-in. butts, is made by binding together with wire enough of these poles to form a fascine about 2 ft. in diameter, and as long as the mattress is wide. The mattress consists of bundles or fascines of the willow brush, each fascine about 12 in. in diameter. The brush in each fascine is bound around by wires and the fascines are lashed together by wires wound around the head and extending longitudinally the length of the mattress. These longitudinal wires are in courses on the upper and lower sides of the mattresses, and are from 5-16 to ½-in. in diameter. After the head of the mattress has been completed the wires that are to be in the bottom course are adjusted and the work on the first fascine is started.

A platform is erected above the decks of the scows on which the fascines are made. Over this platform a number of light frames, on which the brush is assembled into the fascines, are built. The willows in the fascines are arranged so break joints and as a bundle is formed it is bound together at intervals with rope yarn and slid down ways, which are a continuation of the erecting frames, to the mattress head. A gang of men then sew the bundle to the bottom wires with ¼-in. wire.

After several fascines have been built and tied in place the portion of the mattress is attached to anchor lines and to slip lines about 16 ft. apart. The slip lines are attached to timber heads on the mooring barges during the construction of the mattress and guide the latter when the complete mattress is being submerged.

After about 100 ft. of a mattress has been completed the full width, and is afloat, lines of poles are placed longitudinally about 8 ft. apart the full width of the mattress. These poles are wired to the fascines and to the bottom strands of wire. They stiffen the mattress longitudinally and serve as barriers to prevent the stone ballast used in sinking and anchoring the mattress from shifting while the mattress is being submerged.

The stone ballasting is started when the construction of the mattress is within a day or two of completion. Stone is first placed uniformly over the mattress until the latter is just awash. The weaving barges are then withdrawn and the mat pulled close to the bank and anchored laterally. Barges loaded with broken stone are then lashed end to end, their combined length equaling the width of the mattress. Rock from the mooring barges is then thrown on the head of the mattress until the latter sinks sufficiently to permit the stone barges to be pulled up across the mattress immediately down stream from the mooring barges. The lines attached to the mattress are paid out from the mooring barges as stone is thrown over from the rock barges and the submergence proceeds. The slip lines are always paid out in such a way as to maintain a uniform tension on them and thus preventing the mattress from curling. The mooring, or anchor, cables are slackened after allowing the mattress to settle into position, the shackle pins attaching them to the mattress are pulled out and all mooring chains and cables are recovered.

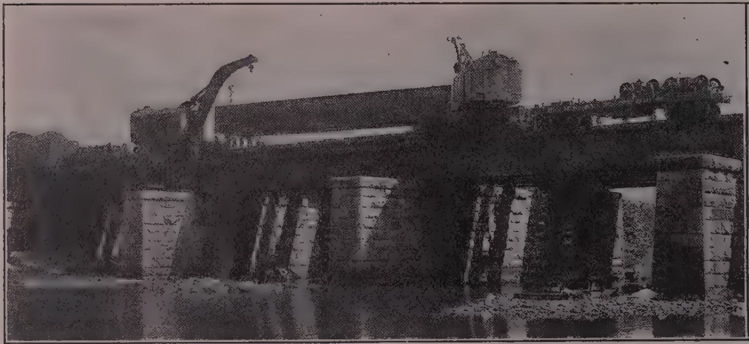
The stone required for sinking is ordinarily about ¾ cu. yd. per square (100 sq. ft.) of mattress. With a full force of trained men the progress attained in mattress building is about 120 ft. per day. After the mattress is down the upper bank is brought to about a 1 to 3 slope by hydraulic graders, and is paved by hand, first with a layer of spalls and then with one-man stone, carefully laid so as to leave no interstices through which the force of the current might reach the bank and erode it.

The cost of revetment work by the Government in the first and second districts, Mississippi River Improvement, at Fletcher's Bend, during the season 1904-05 was as follows: channel mattress, per square (100 sq. ft.), $7.73; connecting mattress, per square (100 sq. ft.), $10.04; hydraulic grading, per cubic yard, $0.038; paving bank, per square yard, $1.08.

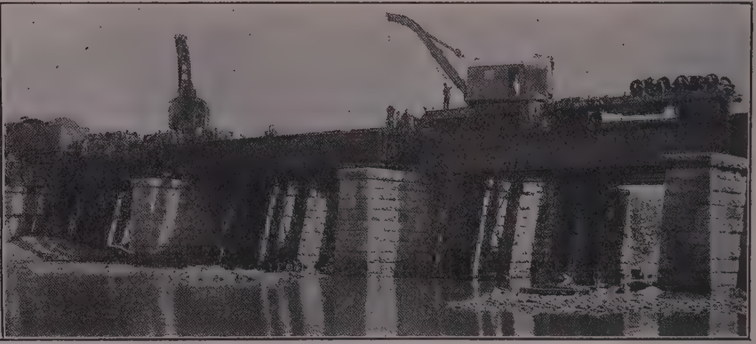
The Erection of the Shenango Rive Bridge.

Recent improvements on the Pittsburg & Lake Erie R. R. included the construction of two additional tracks parallel and adjacent to the existing double track main line across the Shenango River, near New Castle Junction, Pa., without interfering with traffic or interrupting the train schedule. The original structure comprised five plate-girder deck spans, with stone masonry piers and abutments. The substructure was extended far enough to receive four lines of girders spaced 8½ ft., 30½ ft. and 8½ ft. apart, and plans were devised and successfully executed for erecting the new superstructure on it from the old superstructure without falsework.

The ten new spans, 39 ft. apart on centers, each consisted of a pair of independent deck girders 36½ ft. long. They are 78½ in. deep and 8½ ft. apart, on centers, made with 7/16-in. web plates in three lengths and with 8 x 8 x ⅝-in. single length flange angles reinforced with three thicknesses of 18-in. cover plates. On account of the distance between girders they are connected by 35-in. plate-girder floor-beams, with the end sections of their webs extended below the lower flanges to make gusset plates bracing them to the main girders. Stringers, 23½ in. deep, are seated on the top flanges of the floor-beams and their top flanges are connected to the top flanges of the main girders by ⅜-in. horizontal plates, 3 ft. long, riveted to their under sides, at the points where the stringers are connected to the transverse braces and later angles. The lower flanges of the main girders are braced with zigzag lateral angles. Each span when riveted up complete with floor-beams, stringers, and all bracing weighed about 50 tons and was delivered on two flat cars run across the river on one of the old tracks. On the other old track a pair of derrick cars were run opposite the new span, and lifting it at the ends, removed it from the flat cars, swung it between themselves, across the other old track on which they were seated and deposited it in its permanent position on the ends of the piers. The operation was repeated for all of the girders in one line and then the relative positions of the derrick cars and delivery cars were changed so that the derricks working in the opposite direction handled the spans from the other track to their permanent position on the opposite side of the bridge.



Unloading Complete Span from Cars.



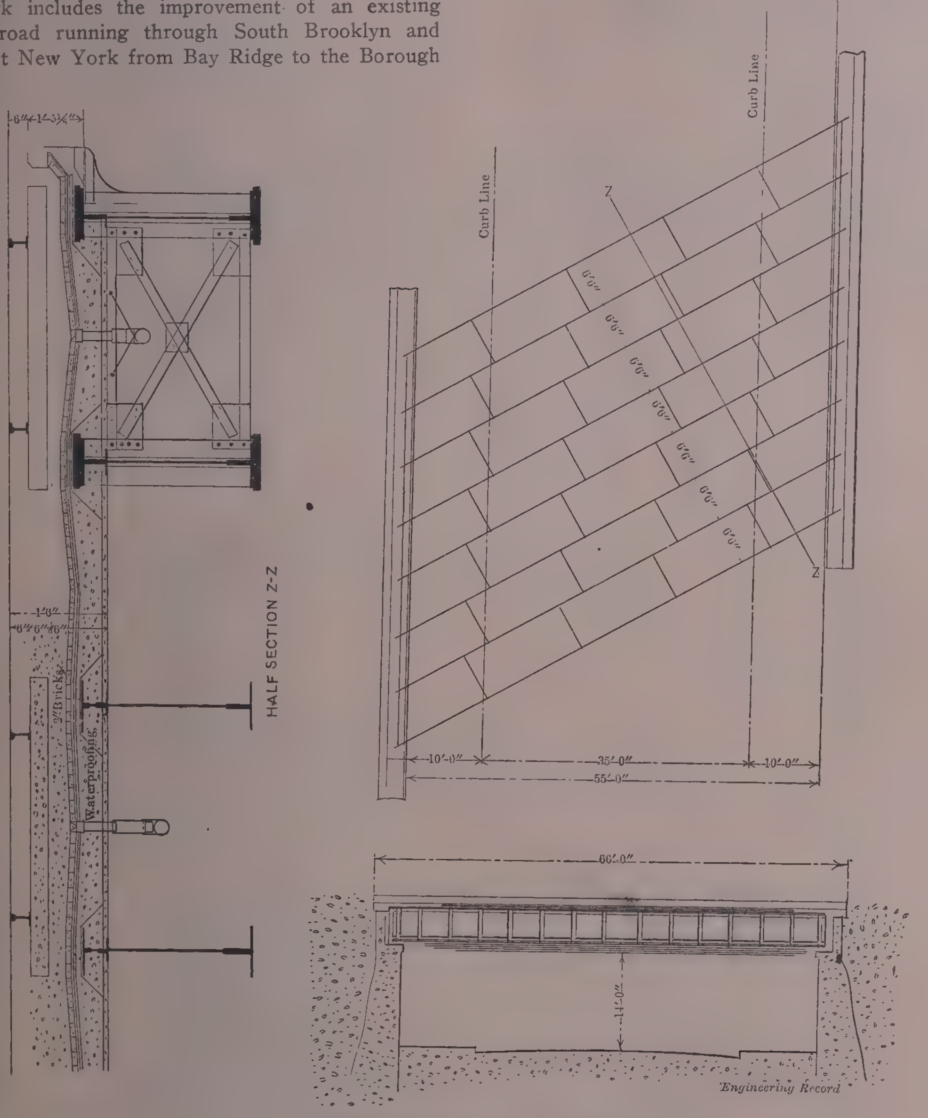
Depositing Span in Permanent Position.

By this method all riveting was completed at bridge shops, and after the erection of the bridge it only remained to put on ties and rails before opening the new spans to traffic. The total weight of steel in the ten spans was 500 tons, which was erected in the remarkably short time of twelve hours.

The work was designed for the Pittsburg & Lake Erie Ry. Co., by Mr. Albert Lucius, New York, was built by the Penn Bridge Co., and was erected by the Lucius Engineering & Contracting Co., of Pittsburg, New York and Chicago.

Bay Ridge Improvement Bridges.

The Bay Ridge improvement for the Long Island railroad and the Brighton Beach improvement for the Brooklyn Rapid Transit Company, both contemplate a large amount of track elevation and depression of a similar character but are entirely separate and independent, except that both are being executed under the supervision of the Brooklyn Grade Crossing Commission, which was created under an act of the Legislature of the State of New York, Laws of 1903. The Bay Ridge improvement, of which this article particularly treats, is under the general direction of the engineering department of the Long Island Railroad Co., represented by Mr. L. V. Morris, engineer. The work includes the improvement of an existing railroad running through South Brooklyn and East New York from Bay Ridge to the Borough Line, a distance of 10 miles, where a connection is made with the proposed New York Connecting R. R., running through the Borough of Queens to a bridge over the East River, Wards Island and Randalls Island to Port Morris, where connection will be made with the New York, New Haven & Hartford R. R.



Rockaway Avenue Bridge.

The work involves the elimination of all grade crossings and provides for a great number of new highways. There will be about 5 miles of depression in open cut, 4 miles of elevation on embankments and 1 mile of tunnel construction. In addition to this, the Manhattan Beach Ry. is to be elevated on embankment from the junction point to Manhattan Beach, a distance of 3 miles, making altogether a total line of 7 miles to be double-tracked and 6 miles with four tracks.

There will be approximately 60 bridges, comprising both railroad structures and overhead highway bridges. Of the latter there will be 10 viaducts, varying in length from 200 to 800 ft., and from 50 to 100 ft. in width. Deck bridges are used wherever there is sufficient headroom. In narrow streets, or where the crossings are at right angles, the bridges are made with single spans up to about 60 ft. in length, in other places the girders are supported on columns just back of the curb lines, thus dividing the space into three spans.

The track is laid over all bridges in stone ballast, which provides for the continuity of the road bed from the embankment across the abutments and greatly promotes satisfactory maintenance. The ballast is in all cases supported by solid floors of reinforced concrete, carried by steel beams and girders arranged so as to limit the spans of the concrete to a maximum of about 5 ft., the minimum thickness of the concrete being 8 in.

Preliminary studies were made developing several comparative designs for floor construction; from these the most satisfactory features have been combined to secure three standard types of bridges to which all of this construction substantially conforms, namely, railroad deck spans, railroad through spans, and highway spans.

Among the most important considerations determining the selection of the concrete floor system were: the diminution of impact effects by the increased inertia; the reduction of maintenance charges; and the protection of streets from drip, dirt, etc. It is true that the adoption of ballasted concrete floors increases the dead load transmitted to the main girders to a total three or four times that due to ordinary cross ties laid on open stringers. Notwithstanding this increase, however, the main girders have been designed with the same sectional areas as would have been provided for wooden floors. The idea of this construction is that the inertia of the concrete and ballast reduces the effect of impact more than enough to compensate for the added dead load.

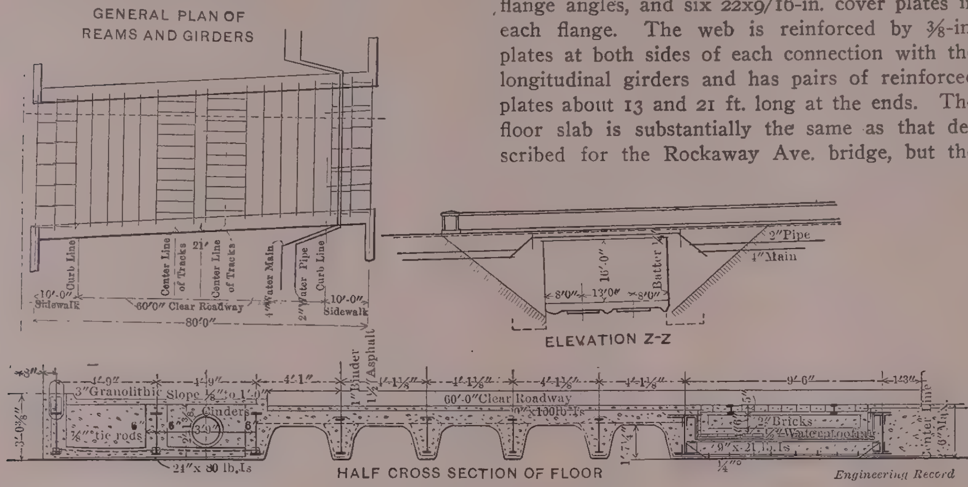
The fundamental consideration in the design of the concrete floor was to make a composite construction in which the reinforced concrete and the principal steel members would be thoroughly bonded together so that the reinforced concrete shall develop suitable beam and arch action, thus utilizing its own strength in transferring the live load to the steel members, which it also protects and bonds together. Special provisions are also made for very thorough waterproofing and drainage.

The construction was designed in accordance with the Long Island Railroad Co.'s general specifications for steel structures, of 1905, as regards loads, impact, etc., but the assumption was made that the track ballast and concrete would distribute the driver loads (Cooper's E 50) over the length of the wooden ties transversely and from center to center of drivers, 5 ft., longitudinally, and when it is understood that the impact allowance for the floor beams is 100 per cent. of the live load and that after the concrete is properly reinforced, and bonded to the steel work, it will materially stiffen and strengthen it, the above assumption appears to amply satisfy all considerations of strength and safety.

The 1:2:4 concrete is made with Portland cement and ¾-in. broken stone reinforced with twisted steel bars from ¼-in. to ⅝ in. square, the smaller ones being laid transverse to the lines of stress in order to prevent danger of cracking. The reinforcement is proportioned according to Thacher's formulæ which give about 1 per cent. of steel for the cross sectional area of the slab. It is required that the steel must be free from paint, grease, or dirt when bedded in the concrete. The total thickness of the floor in deck spans averages about 2 ft. and in through spans about 3 ft. Train loads are under no circumstances imposed on the concrete until it is at least ten days old and in many cases much older. It is expected that the first cost of this type of floor may be easily 50 per cent. more than that of the old style floor, with open steel stringers, but it is probable that considering the cost of maintenance, the capitalization will be little if any greater and that much more satisfactory traffic conditions will be secured.

The Rockaway Ave. bridge affords an illustration of the typical short span deck structure for skew crossings. It carries four tracks across the street and sidewalks with a vertical clearance of 14 ft. There are eight 66-ft. plate girders 6½ ft. deep braced together in pairs, one for each track, with ordinary sway frames. The web plate, ½ in. thick, is made in two half length pieces, and the 8x8x⅝-in. flange angles and the 19-in. cover plates are made in single unspliced lengths. The ends of the lower flanges have sole plates bearing on riveted pedestals about 9 in. high which give 24x28-in. bearings on the masonry. Horizontal 3½x3½x⅜-in. shelf angles with their vertical flanges up, are riveted to both sides of the girder webs from end to end, with their horizontal flanges flush with the lower edges of the main flange angles.

These shelves receive the continuous concrete floor slabs which enclose the top flanges of the girders above which they are about 2 in. thick. The upper surfaces of the slabs are pitched to longitudinal lines between the centers of the girders where they have a minimum depth of 8 in. They are reinforced by ⅝-in. transverse rods 6 in. apart, every alternate rod being made continuous across the full width of the bridge by 2-ft. laps splicing them over the top flanges of the girders where they are bent upwards as shown in the accompanying cross-section. The other transverse rods reach only from girder to girder and are not bent upwards at the ends. The ¼-in. longitudinal rods are spaced 12 in. apart and are lapped 12 in. for splices. The concrete is continued 2 ft. beyond the center of each outside girder and is carried up 17½ in. above the top flange angles to form a low parapet or fascia girder which is reinforced by the projecting ends of the transverse rods and serves to retain the ballast.



Gravesend Avenue Bridge.

The upper surface of the concrete is thoroughly waterproofed with a ½-in. thickness of felt and asphalt on which ordinary red brick are laid flat on a ½-in. mortar bed so as to protect the waterproofing from accidental blows of pick or bar when the trackmen adjust the ballast. The drainage from the center gutters is delivered through short 2-in. vertical cast-iron pipes to lines of 4-in. wrought iron pipes pitched both ways from the center of the span to the back walls of the abutments through which they pass and deliver to the sewers behind them.

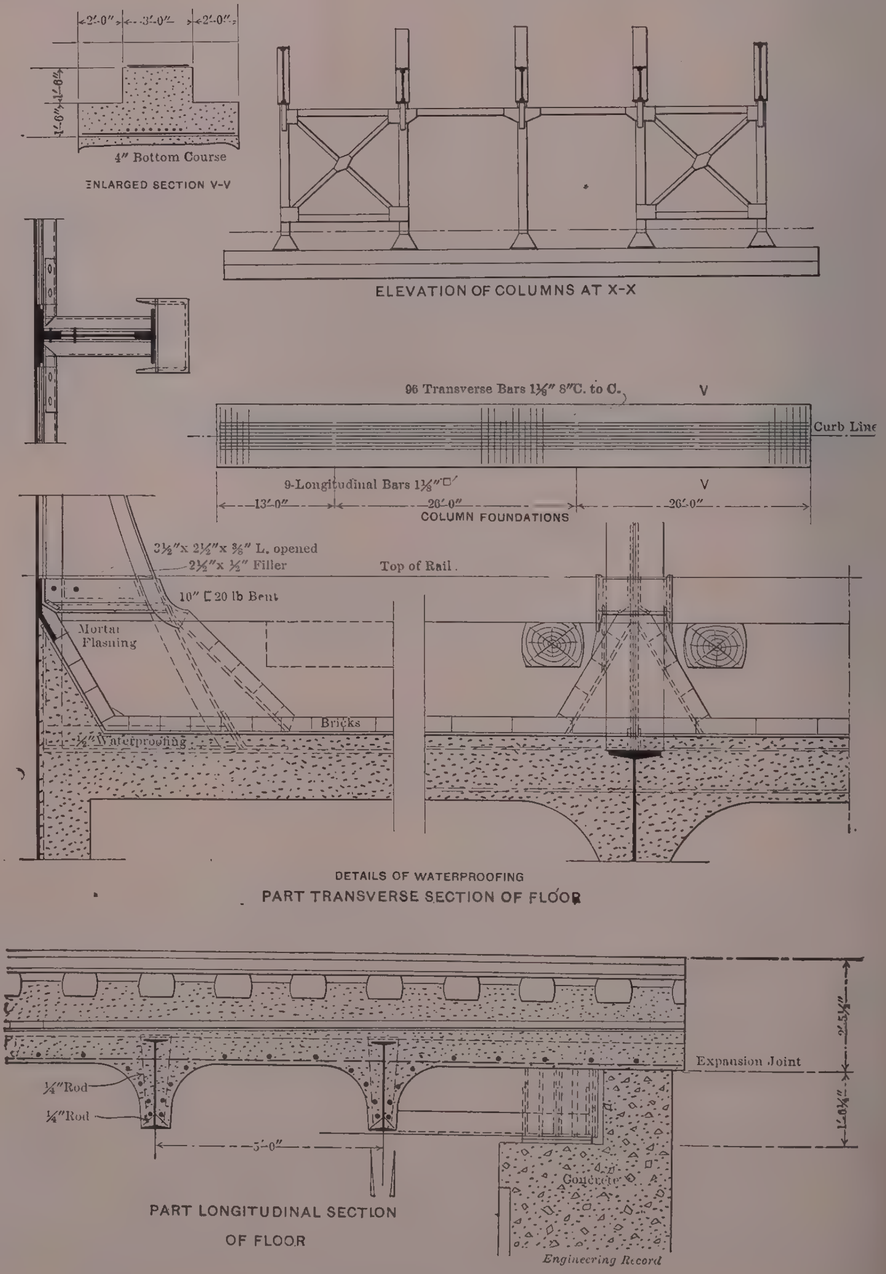
The elaborate character of some of the structures is illustrated by the Ralph Ave. and Ave. D bridge which crosses the intersection of two streets nearly on its diagonal. Here the maximum distance between abutments is about 190 ft. on one side, and about 116 ft. on the other side. To reduce the span, the longitudinal girders are supported by a column bent nearly coincident with the axis of Ralph Ave., and by another bent parallel with it on the building line of the same street. The latter bent has only two columns, one on each curb line of Ave. D, and these carry a deep transverse girder to which the longitudinal girders are web-connected like stringers to a floor beam. The columns in the other bent have no transverse girders and each receives the longitudinal girders on its horizontal cap, all as indicated in the diagrams.

The eight columns are set square with the girders and oblique with the plane of the bent, and have a continuous footing of monolithic concrete 74 ft. long, 4 ft. wide on top and increasing by seven offsets to a width of 9 ft. at the base. This is proportioned for a bearing of 5,000 lbs. per square foot on the sand and gravel foundation, but provision is made for reduction of this pressure if conditions demand it when the bridge is built. The top of the column footing is about 3 ft. below the surface of the street and the extended bases of the columns are enclosed in protective masses of concrete that rise a few inches above the pavement. The column loads are distributed on the concrete through grillages made with 20-in. I-beams 7 ft. long. The tops of the columns are kneebraced to the lower flanges of the girders with solid-web brackets having curved 4x4-in. flange angles.

The longitudinal girders are of ordinary construction with 6x6-in. flange angles and 14-in. cover plates and ⅜x72-in. webs. The 72-in. transverse girder 48 ft. 3 in. long, has 8x8x⅝-in. flange angles, and six 22x9/16-in. cover plates in each flange. The web is reinforced by ⅜-in. plates at both sides of each connection with the longitudinal girders and has pairs of reinforced plates about 13 and 21 ft. long at the ends. The floor slab is substantially the same as that described for the Rockaway Ave. bridge, but the longitudinal drain pipes are pitched from both ends of the bridge to the center columns where vertical leaders are carried down to the street level and discharge into an open gutter.

A typical four-track, three span, through bridge is illustrated by the Remsen Ave. crossing, 80 ft. long between faces of abutments. Two continuous concrete footings 52½ ft. apart on centers and 65 ft. long are built in the curb lines and are reinforced with vertical and transverse rods arranged as indicated in the diagram. The longitudinal and transverse rods are arranged as shown in the diagram so as to form a continuous girder distributing the load of the bridge on the foundation with a maximum intensity of 5,000 lbs. per square foot. The transverse reinforcement rods are spaced uniformly from end to end of the footing, although a portion of them are omitted in the plan so as to avoid obscuring. Each of the longitudinal rods is made in three lengths with abutting ends, joints in adjacent rods being staggered so that each rod is spliced by the alternate ones.

On each footing are seated five vertical columns with H-shape cross-sections made with one 11x⅜-in. web plate, four 5x3½x⅜-in. flange angles and two 12-in. 30-lb. flange channels. The feet of the columns have extended bases with 26x43-in. bottom plates, and to the tops are riveted solid web knee-brace brackets, with cap plates



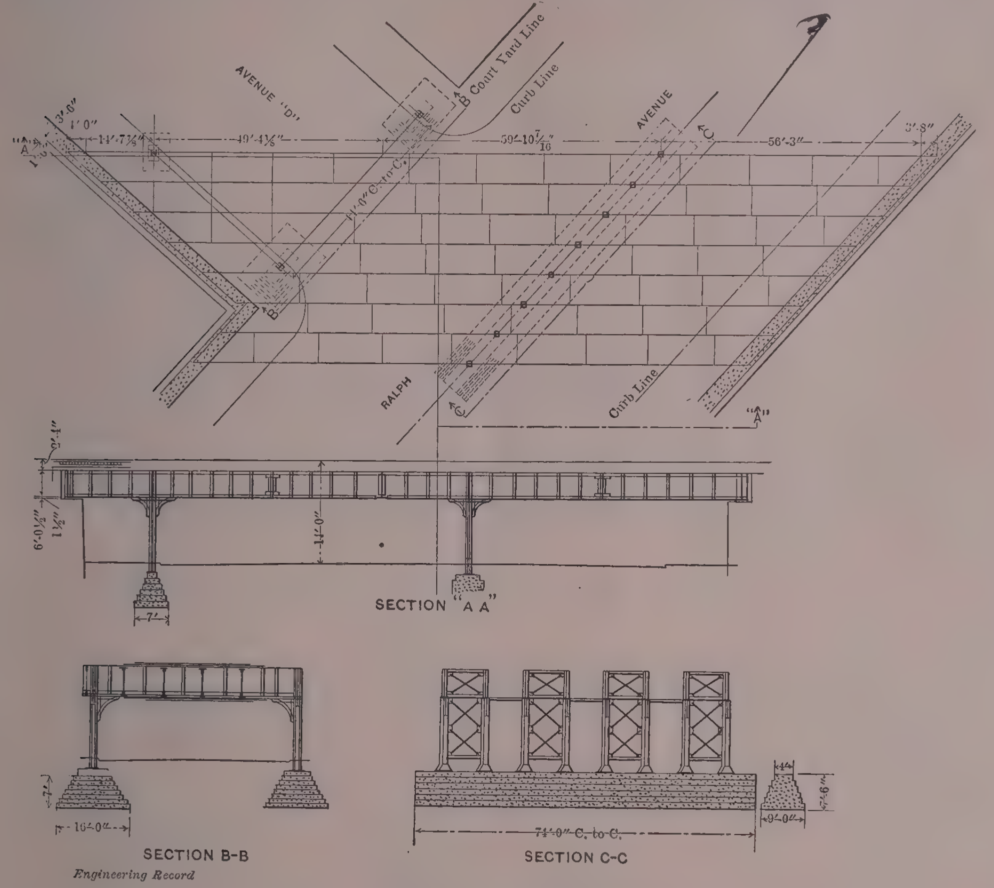
Remsen Avenue Bridge.

14 in. wide which are continuous across the column top and receive the lower flanges of the girders. In the center three lines the main girders have a depth of 96 in. and are made with a 7/16-in. web plate spliced at the center of the span and with two 6x6x⅝-in. angles and four 14-in. cover plates in each flange. The upper corners are rounded and the end vertical web-stiffener angles are field-riveted to those of the side spans which haxe 36x9/16-in. webs and 6x6x½-in. flange angles without cover plates.

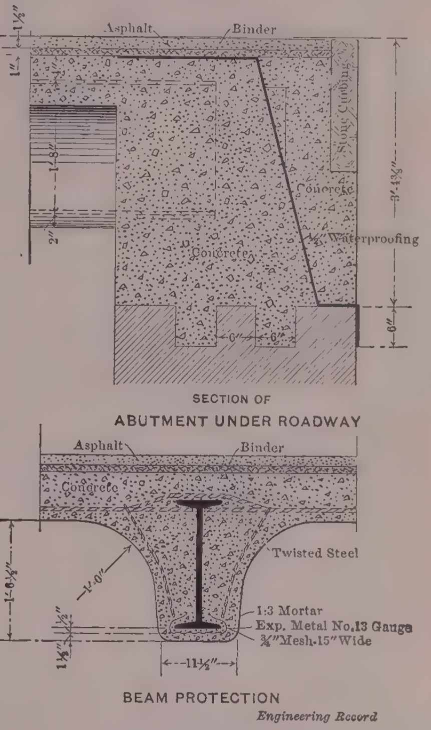
The outer lines of girders are made, for appearances' sake, with a uniform depth of 72 in. They have web plates ⅜ in. thick and 6x6x½-in. flange angles, thus giving excess of material in the short side spans. Additional transverse stability is given to the outer ends of the 36-in. girders by providing for them extended base plates stiffened by transverse diaphragms riveted to the web stiffener angles. The floor beams are 24-in. 80-lb. I-beams spaced 5 ft. apart, and web-connected to the main girders with their lower flanges flush with the second cover plates of the latter. The upper flanges are field riveted to knee-brace gusset plates having curved flange angles extending to the top flanges of the main girders.

The floor beams are protected by concrete in which they are embedded, with the exception of the lower surfaces of their bottom flanges, which are flush with the bottom of the concrete. The concrete around the beams is continuous with that of the floor slabs between them and is joined to it with curved fillets which give an arch-like appearance to it in longitudinal section. The slabs are 11 in. thick and have the upper surfaces pitched to drain pipes in the middle of the center line of each track.

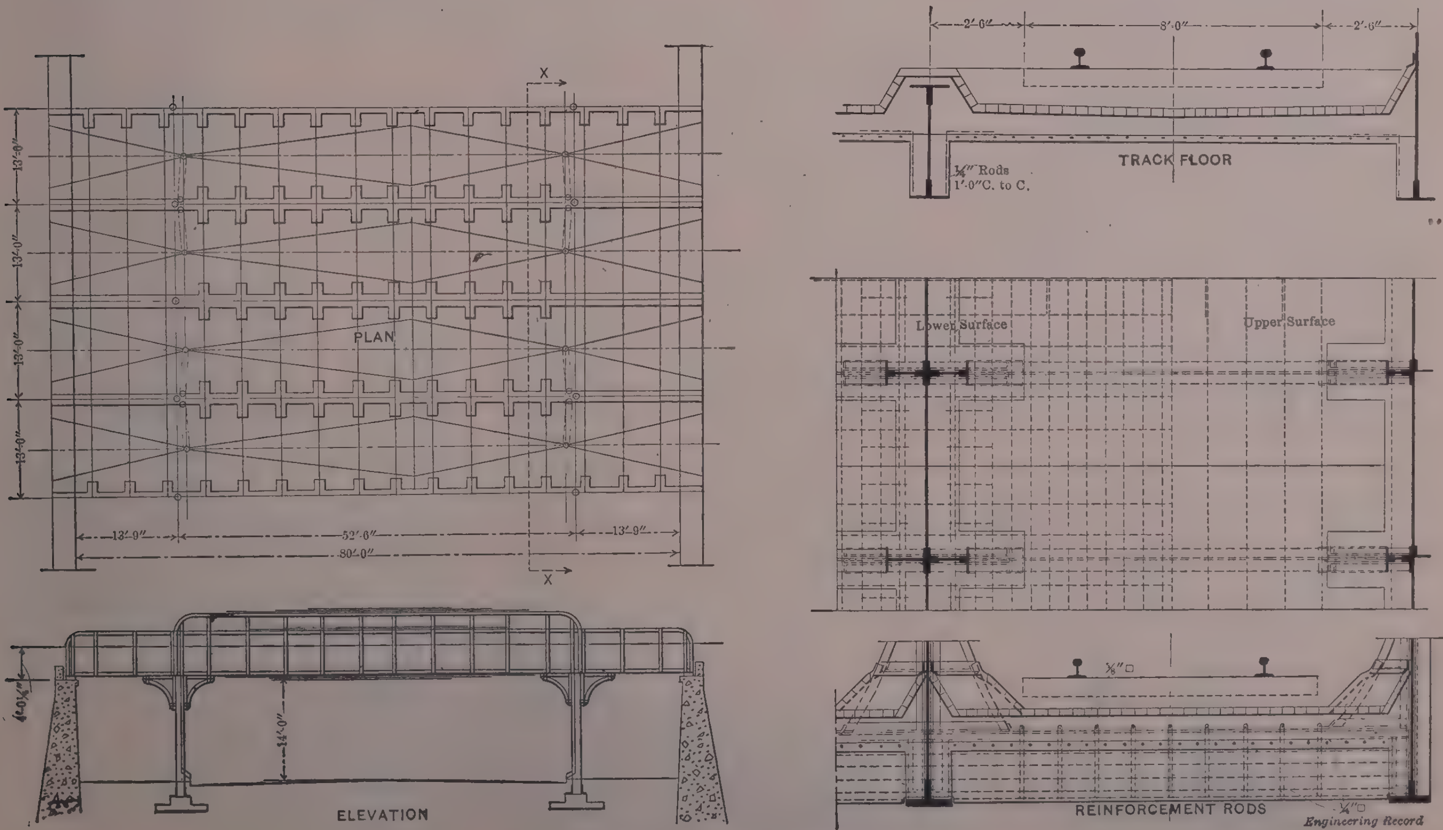
The concrete is reinforced with ⅝-in. longi-



Ralph Avenue Bridge.



Gravesend Avenue Bridge.



Remsen Avenue Bridge.

tudinal bars, 12 in. apart in the upper surface and 6 in. apart in the lower surface. These bars pass through holes punched in the webs of the floor beams and are made continuous from end to end of the slab by overlapping 2 ft. at each joint. Transverse ¼-in. rods, 12 in. apart, are bedded near the lower surface of the concrete. Special reinforcement is provided for the concrete enclosing the floor beams by transverse ⅝-in. rods and vertical ¼-in. U-bars. At each end of the bridge the slab projects over the top of the back wall of the abutment and rests on it with a sliding expansion joint. The upper surface of the concrete is covered with a ½-in. coat of waterproofing and a single course of red bricks laid flat in cement mortar and grouted. Above this there is stone ballast, 4 in. deep, to the lower side of the ties, 6 in. thick.

At the longitudinal edges of the slabs the concrete is carried up at an angle of about 30 deg. to the base of the rail, the waterproofing and brick protection being made to correspond. This flashing is carried around the gusset plates at each floor beam and is very carefully molded to them so as to insure complete protection of the structure from the ballast and prevent any leakage of rain water between the concrete and the steel work. Considerable difficulty has been encountered in securing a suitable finish at the upper edge of the flashing and in protecting the joint there so as to thoroughly exclude the water.

This desired arrangement has finally been attempted, as shown in the details, by riveting to the web of the main girder and that of the gusset plates a light horizontal angle with the horizontal flange bent downwards forming an oblique section and engaging the upper edge of the brick flashing. On the inclined flange of the gusset plate, the bent angle is replaced by a short curved section of 10-in. channel.

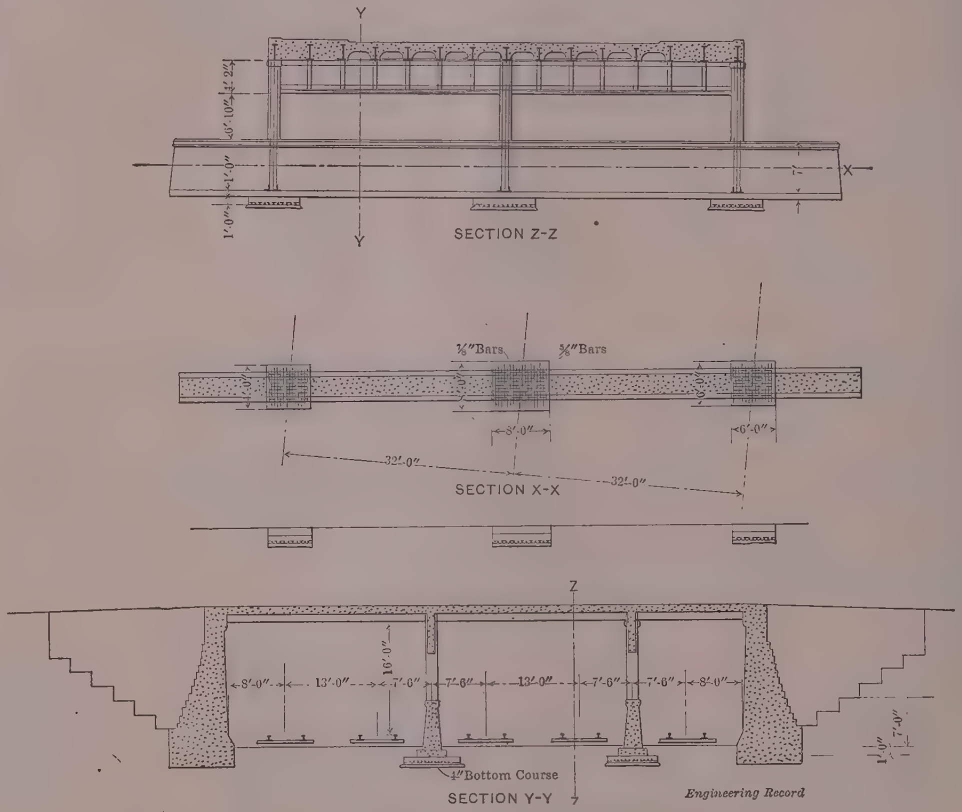
The floor construction in the side spans is modified slightly as shown in the cross-section so as to carry the concrete, waterproofing and brick course over the top flanges of the 36-in. girders.

A modification of the Remsen Ave. crossing is illustrated in the Ave. G crossing, which is a five-track bridge on a very sharp skew. The perpendicular distance between the faces of the abutments is 64 ft., while the total length of the bridge is about 255 ft. There are six lines of girders 13 ft. apart on centers, each line consisting of an 89-ft. 10-in. center span and two 19-ft. 8-in. end spans, supported by the abutment walls and by rows of columns parallel to them on the curb line. The columns are seated without extended bases on grillages of three 18-in. I-beams 7 ft. long, on top of 10x13-ft. concrete pedestals about 30 in. high, with two layers of reinforcement bars about 6 in. apart near the lower surface. The upper tier of rods are ¾ in. square and the lower tier at right angles to them are 1⅛ in. square. The 89-ft. 10-in. girders are about 10 ft. deep and have 8x8-in. angles and 17-in. cover plates in the flanges which are each reinforced in the center of the span by a pair of 8-in. web plates 62 ft. long.

The end girders are 48 in. deep with 6x6-in. flange angles and 14-in. cover plates. They are seated with solid-web knee-brace brackets on the tops of the columns as in the Remsen Ave. bridge, but the floor system varies from the latter in that it is made with 12-in. I-beams, 12 in. apart. Every sixth I-beam weighs 40 lb. per foot, and is field riveted to gusset plates extending to the top flange of the main girder. The intermediate beams weigh 31½ lb. and are connected to the girder web with pairs of flange angles. All of the floor beams are notched at the ends to clear the lower flanges of the girder. The concrete slabs have a minimum thickness of 13½ in. at the center line of each track and from this point the upper surface slopes upwards nearly to the webs of the main girders where it joins the flashing. The concrete is not reinforced and the distance between the I-beams is so small that the latter take the loads directly and the concrete serves only to protect them and provide a continuous surface retaining the ballast.

The Gravesend Ave. bridge illustrates the construction adopted for a short span structure carrying a highway and street car tracks over two tracks of the Long Island R. R. The bridge is very wide in proportion to its length, which is only 29 ft. between the faces of the abutments. The steel work consists mainly of fourteen 20 and 24-in. I-beams, about 32 ft. long, seated on the abutment walls to carry the roadway, and of four plate girders 22 in. deep and 33½ ft. long, arranged in pairs and connected by 9-in. 21-lb. I-beams, 33 in. apart and carrying the street car tracks. The roadway girders support a concrete slab 7½ in. thick which extends 4 in. above the top flanges of the I-beams and is made continuous around the lower flanges.

The upper surface of this slab is covered with 1 in. of binder and 1½ in. of standard asphalt pavement. The concrete is reinforced by horizontal rods ⅝ in. square and 6 in. apart transversely and ¼ in. square and 12 in. apart longitudinally. Vertical ¼-in. stirrups 12 in. apart reinforce the concrete protection for the I-beams. At each side of the bridge there is a 9½-ft. sidewalk with a removable granolithic floor slab 3 in. thick which covers two longitudinal panels between the I-beams. In these panels the construction is made special and the horizontal concrete slab is depressed to the lower flanges of the I-beams, leaving chambers above them which are temporarily filled with cinders with a view of providing space for the pipe lines or conduits which may be required hereafter.



Brooklyn Avenue Bridge.

The concrete protection for the outside I-beam is continued above the top of the I-beams to the level of the granolithic slab and contains vertical ¼-in. U-bars which project above the surface to form bonds for the concrete balustrade which is cast separately from the floor slab. The street car rails are spiked to cross ties bedded in stone ballast carried on slabs of concrete reinforced by ⅝-in. transverse rods and protected by waterproofing and bricks in the manner previously described. Another panel between longitudinal I-beams is made special to provide for duct conduits. Here eight rectangular terra cotta tubes are laid in a horizontal line just above the bottom flanges of the beams and are permanently enclosed by a solid mass of concrete filling the remainder of the space between the beams.

The Brooklyn Ave. bridge is a three-span structure carrying the highway over five tracks of the railroad at a clear height of 16½ ft. It is made with fifteen lines of 20 and 24-in. longitudinal I-beams, spaced 4½ ft. apart and supported by the abutment walls and by two intermediate transverse bents. Each bent has three vertical columns web connected to two plate girders 48 in. deep and 32 ft. 1½ in. long on centers which carry the longitudinal beams seated on their top flanges. The columns have I-shape cross sections and extended bases seated on reinforced-concrete footings. These footings are made continuous, extending from end to end of the bent and are continued up above the surface of the ground forming collision walls and enclosing the columns to a height of 7 ft. The floor slab in this structure resembles that of the Gravesend Ave. bridge except that in it no provision is made for trolley tracks. The sidewalk construction is the same as above described, with two panels under each sidewalk filled with cinders to provide for future conduits.

On account of the locomotives passing underneath these highway structures special care is taken to protect the steel work from gas and smoke, no portion of it being exposed except a small part of the columns between the girders and the collision wall. The floor slab is extended below the lower flanges of the longitudinal beams and the transverse girders are entirely enclosed by solid masses of concrete somewhat thicker than the width of the cover plates and firmly anchored to the girder by six horizontal bolts passing through holes in the web.

The details of the structures were designed under the direction of Mr. J. B. French, engineer of bridges for the Long Island R. R., and are being constructed under his personal direction. The structural steel is being fabricated by Messrs. Milliken Bros., New York. Some of the substructures have been built and the structural steel is now being manufactured in the shops.

The Relation Between Some Physical Properties of Bitumens and Oils.

A paper read before the American Society for Testing Materials by Mr. A. W. Dow.

There are at the present day a number of complex organic liquids of greater or less viscosity that are largely employed in manufacturing, or produced directly for the market. The materials to which I refer are lubricating oils, oils and light tars for treating road surfaces, and bitumens for waterproofing and impregnating felts and for use in the paving industry. These products have caused analysts and engineers considerable difficulty in devising tests that will be of practical value in rating their comparative value. The determination of the chemical constituents of these materials is practically useless, as these constituents have little or no bearing on their physical properties. Service tests are impracticable, as they require too much time, and, besides, it is impossible to have the same conditions in any two such tests. There are at present a few physical tests that are made which are of some value, but the information thus gained is far from what is desired to be ascertained. It is evident from this state of affairs that there must be one or more physical properties overlooked that play a most important part in the practical value of these materials and it is my purpose in this paper to demonstrate from results of tests and investigations on asphalts and like bitumens that the missing factor in these tests is probably that of surface tension of the materials under discussion. I will also discuss the possible physical conditions existing in these materials that give them their different properties in the hope that it may be an aid in the formulation of tests.

In my discussion on this subject I have chosen to class asphalts and other apparently solid bitumens under the heading of liquids designating them hyper-viscous liquids because they most closely resemble this class of matter in their physical properties. This is not at all novel to those familiar with modern physics, as it has been demonstrated that there is practically no dividing line between solids and liquids and that the same physical laws govern their properties. Tammann, a well-known authority, even goes so far as to call all solids that are not crystalline and which therefore have no definite melting point, supercooled liquids.

The laboratory physical tests employed by the author in the examination of asphaltic bitumens are: susceptibility of the material to changes in temperature, its ductility, and its brittleness.

The susceptibility to change of temperature is ascertained by taking the penetration of the bituminous cement at different degrees of temperatures. Penetration as considered in this connection is an arbitrary term that has been adopted in the asphalt industry. It refers to the distance a weighted needle will penetrate into a bituminous cement under a given weight in a given time. There have been one or two machines devised for making this penetration test, but the one in most general use was devised by myself some years ago.

The ductility of a material is determined by ascertaining the distance in centimeters that a briquette made of the material will elongate before breaking.

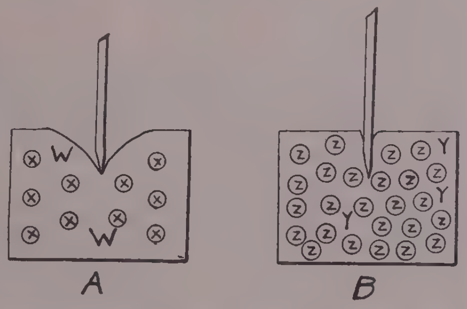
As the apparatus for determining the penetration and the method of making this test, as well as that of ductility have been described before this Society, I will not again take them up at the present time.

The brittleness of a bitumen is determined by ascertaining the distance a 25-gram weight must drop to break a prism of the material having a section 1 cm. square and a length of 10 cm. resting on supports 8 cm. apart. The test is usually made at the temperature of 32° Fahr.

On comparing the data obtained on bitumens with these tests, it was noticed that a definite relation existed between the degree of susceptibility to change in temperature, the ductility, and the brittleness of bitumens.

In Table I will be found the results of tests on several bitumens. These materials are arranged in the order of their susceptibility to change in temperature, the most susceptible being at the top of the column. The numbers in the first four columns to the left are the penetrations of several bitumens taken under various conditions indicated over each column. The next two columns to the right give the ductility of these materials taken at 0° and 25° Cent. In the last column to the right will be found the brittleness of these materials at 32° Cent.

In comparing the results in this table it is seen that in nearly every case a definite relation exists between these three physical properties; that is, the more susceptible to change in temperature, the more ductile and at the same time the more brittle is the material. While all hyperviscous liquids do not appear to absolutely comply with this law, yet they follow it with sufficient closeness to enable a close approximation to be made of any two of the above properties from a knowledge of the third. I would also call to your attention that in the few cases where these hyperviscous liquids do not follow the general rule, that they closely resemble each other and it may be that with more perfect methods and materials free from foreign impurities, a still closer conformity may be expected.



Diagrammatic Composition of Materials.

Still another interesting relation is brought out and is exhibited in Table II. These results were obtained by taking the penetration of some of the material represented in Table I with the same weight, and at the same temperature, but varying the time interval. As in the other table they are arranged in the order of their susceptibility to change in temperature. These results show that the greater the ductility the greater the variation between the penetration taken at the different time intervals; that is, in testing two bitumens, one very ductile and the other lacking in ductility, let us suppose that they have the same penetration under 100 grams, No. 2 needle, for 5 seconds at 77° Fahr. If the penetration is now taken on these two samples at the same temperature with the same needle and weight, but increasing the time to 1 minute, it is found that the more ductile one will permit considerably greater penetration than the less ductile one. To test this rule the same experiment was repeated at another temperature and with different weights acting on the needle and the same relations were found to exist. Still another property appears to have a close relation to those just mentioned. The more ductile bitumens are the more fluid; that is, of two materials both of the same penetration when tested at 77° Fahr., the one that is the more ductile will flow the more readily into an aperture or be more readily flattened down by its own weight. In fact, a very hard California oil residue will have considerably more flow to it than a soft hydroline bitumen.

Having established the above relations between the various asphaltic bitumens I turned my attention to the testing of oils, applying to them the viscosity test which I considered the nearest equivalent to the penetration tests, and fully expected to find the same relation between results obtained under different conditions. Two heavy oils having the same viscosity on a Doolittle viscometer at 45° Fahr. were selected for this test. The one oil had the property of being readily absorbed into the surface of a road, while the other had not. The viscosity was determined at every 10° from 45° to 75° Cent. I was much surprised to find that the tests on these oils ran parallel with each other at every temperature. Experiments were made on other oils, but no great variation could be detected in the viscosity at different temperatures with the exception of one paraffine oil which evidently contained scale paraffine melting at 55° Cent. and producing a rather sudden jump in viscosity.

Tests were then made with a viscometer of my own design which consists of a cylinder 2 cm. in diameter of equal bore throughout, fitted with a plunger 1 mm. less in diameter. This plunger is used in the frame of the penetration machine in place of the needle, and the distance the plunger sinks under a weight of 50 grams in 5 seconds is taken as the viscosity of the oil. The viscosity by this apparatus can be compared to that obtained on the regular pipette viscometer. The results obtained at different temperatures also did not materially differ from those given by the Doolittle viscometer. From these results it is evident that the penetration test does not entirely, if at all, correspond to the viscosity test, and the question as to what other physical laws govern this test naturally arises.

TABLE I.
Physical Properties of Bitumens.

Class of material.	Penetrations: 200 gm., 1 sec., 0°.	100 gm., 5 sec., 25°.	50 gm., 5 sec., 38°.	50 gm., 5 sec., 46°.	Ductility, 0°.	Ductility, 25°.	Brittleness, 0°.
Coal tar pitch, old	3	38	130	310	—	200+	—
Coal tar pitch, new	7	50	162	371	—	200+	—
Rosin and mac. oil	6	49	170	395	—	200+	3
Reduced Cal. oil..	7	50	156	366	13.1	200+	7
J. & B. Cal. & Tex.	10	52	134	338	11.3	200+	—
Bermudez & Tex..	12	51	114	265	6.3	52	—
Trinidad & E. Res.	13	50	110	257	5.6	37	8
Cuban & Texas....	19	53	101	195	5.0	23	12
Hydroline & Tex..	27	51	90	178	3.5	9	12
Maricaibo & Tex..	26	53	80	135	3.1	9	52
Hyd'line B. & Tex.	26	52	56	113	4.0	6	57+

TABLE II.
Penetration of Materials by No. 2 Needle during Varying Time Intervals.

Material.	15° 200 gm.			15° 100 gm.		25° 100 gm.	
	5 s.	1 m.	5 m.	5 s.	5 m.	5 s.	1 m.
Reduced Cal...........	20	62	165	9	104	53	156
J. & B. No. 2 & Cal...	21	63	166	7	103	53	155
Bermudez & Tex.....	24	67	144	10	94	53	129
Hyd. B. & Tex........	39	74	112	27	73	55	82
Rosin & mac. oil......	12	72	165	18	105	52	190

This question and the relative physical properties of the different asphaltic bitumens have been the occasion of considerable speculation on my part in the hope that they might reveal something as to the physical constitution of these bodies. I am inclined to believe for several reasons that these relative physical properties indicate the degree of solution in each other of the various compounds composing these materials. That is, the more complete the solution of the compounds in each other the more susceptible to temperature and the more ductile, or, in other words, it would appear that as you progress from the ductile materials toward the non-ductile that the solutions of the various hydro-carbons in each other become more incomplete, resembling in some ways colloidal solutions and in some extreme cases even a state of emulsion. And I might here say that Burton has lately demonstrated that emulsions resemble colloidal solutions in many ways. This theory is still further strengthened by the failure of the viscosity test to coincide with the penetration test and points strongly to the conclusion that the former test is more an indication of surface tension than of viscosity. I believe it also explains the relation existing between the difference in penetration for various time intervals and the properties of ductility and fluidity and the susceptibility to changes in temperature.

Theorizing on the composition of these materials let us suppose that the accompanying diagrams are sections through two samples of materials after the needle has penetrated for 5 seconds, these materials both have the same penetration for this time interval. The one, *A*, is a ductile material that readily loses its shape or flows; the other, *B*, is non-ductile and non-fluid material such as Hydroline *B*. According to the theory the former material is composed of two liquids, *W* and *X*, the latter being in a coloid state in *W*. As this material, *A*, is nearer a true solution there is but little of coloid *X* present and the rigidity of the material is entirely due to its external surface tension, that is, a high-surface tension of liquid *W*.

The other material, *B*, is composed of two liquids, *Y* and *Z*, the latter being in a colloid condition in *Y*. The material owes its rigidity to the surface tension of the particles of the colloidal liquid *Z*, and is but little dependent on the external surface tension of liquid *Y*, which may be of very low surface tension. In other words, this liquid might be likened to a sponge, liquid *Z* being the fibres and *Y* the light low-surface tension liquid held in the pores. It is seen in the first material, *A*, that the first penetration of the needle into it causes a large depression surrounding the needle. In the case of the second material there is little or no depression. It is evident from this that considerable of the work of the needle in penetrating in the first case is in overcoming the surface tension of liquid *W*, while in the second case the surface tension being low the needle meets with little or no resistance, but as it proceeds is retarded by the internal surface tension of the particles *Z*. If now, the needle is allowed to penetrate still longer it is evident that it will penetrate further into the first than into the second material, because it continually meets resistance from the internal tension of particles *Z*. This is further demonstrated by the shape of the surfaces after the penetration of the needle, for although it has penetrated to an equal depth into both samples in the first 5 seconds, the first, *A*, is evidently much softer than the second material, *B*, as it not only has to make a penetration, but carry with it the large mass of material which adhered to the point of the needle.

With two asphaltic bitumens having this internal structure it is easily understood why *A* loses its shape, or, in other words, is more fluid than *B*, even though to the touch or under the penetration test, *A* may be harder than *B*.

If we now apply this theory to lubricating oils I believe it can be readily appreciated why some oils of high viscosity are incapable of keeping bearing surfaces apart and are, at the same time, poor lubricants, while other oils of less viscosity act so well both in keeping bearings apart and in lubricating. If we now suppose two oils to be represented by the two heavy oils tested, *A* and *B*, the former would represent a liquid largely dependent on external surface tension for its viscosity, while the latter would represent an oil with a low external surface tension, but dependent on its internal surface tension for its viscosity.

The first liquid having little or no colloid present in it would readily be squeezed out between two bearing surfaces and at the same time having a high external surface tension would act as a retarding agent between two bearing surfaces. In the case of the second liquid, *B*, it would be just the reverse and the bearing surfaces would be kept apart by the colloid condition and liquid *Y*, having a low surface tension, would act as a good lubricant. This might explain why soaps are used as lubricants because of their colloid conditions and also explains why the addition of lard oil to a mineral oil improves its lubricating properties for heavy machinery because the lard oil enters into a colloid condition in the mineral oil.

If this theory as to the physical constitution of these more or less viscous liquids is correct, as it is reasonable from the above to suppose, it can be readily appreciated what an important factor the examination of the surface tension of oils would play not only in the industry above mentioned, but in numerous others. For example, the character of paint is largely dependent on these physical properties; that is, of two paints the one that has an oil medium approaching closer to what I term a true solution, the closer will the pigment be brought in contact with the surface of the material covered, which I believe is of great importance in paint acting as a preservative.

There has been little or no work done on this line with these complicated liquids and in fact our knowledge of surface tension in any line is very limited. If it were possible to work out a practical way of determining external surface tension and the internal tension of the surfaces of the colloids it would certainly result in great practical value as a means of examining the physical properties of these materials, and would likely prove of great commercial value. It is to be hoped that some physical chemist who is more used to investigating than the author, may take up this subject and it may even seem advisable for this Society to endeavor to have the Bureau of Standards of the Government take up the investigation of this kind with a view of standardizing a method for the examination of lubricant oils and other complex liquids.

THE 50,000-MILE ENDURANCE TEST of the first electric locomotive completed for the New York Central & Hudson River R. R. electric service, was completed in June, the maintenance expense per mile for the entire run amounting to only $0.0126. The operating conditions were much more severe than will be encountered when in regular operation, trains averaging from 200 to 400 tons having been hauled at high speeds and with heavy braking duty.

A Combined Municipal Refuse Destructor and Electric Generating Station.

The town of Westmount, Canada, although included in the area of Montreal, is a suburb of that city and has a municipal government, so that it is really an independent borough. The borough contains about 15,000 people and has practically no factories. After various unsatisfactory experience with incineration and disposal of refuse in others ways, the borough authorities made a detailed investigation of the existing methods of refuse disposal, under the direction of Mr. F. L. Fellowes, borough engineer. The result of this investigation was a decision to erect a refuse destructor in connection with an electric lighting station and operate the latter on steam generated in boilers by the heat produced in burning the wastes in the destructor.

The combined plant consists of the two brick buildings shown in one of the accompanying illustrations. The building at the rear contains the refuse destructor and a battery of steam boilers which are supplied with heat by the destructor; the one in front contains the electric generating equipment. The refuse destructor is the three-grate simplex type, built by Meldrum Bros., of England. The location of the building containing the destructor is at the base of a hill so that all the wastes are delivered on an upper level 50 ft. above the ground floor of the building and descend by gravity to and through the grates. A large sheet metal storage bin built above the charging doors in the top of the destructor setting permits the refuse to be stored when the supply exceeds the requirements, or the capacity of the destructor for fuel.

Refuse Destructor and Electric Generating Station, Westmount, Canada.

The destructor furnaces are served by a 150-ft. Alphons Custodis radial brick stack. The heat and gases generated in the furnaces are directed over the heating surfaces of a battery of steam boilers on their way to the stack. This battery consists of three 200-h.p. Babcock & Wilcox water-tube boilers, each having 2,197 sq. ft. of heating surface and being specially arranged to utilize the heat supplied by the destructor furnaces. The electric equipment in the adjoining building consists of a 75-kw. and two 200-kw. generators, with the necessary auxiliary apparatus and switchboard for such equipment. The engines driving these generators are supplied with steam by the battery of three 200-h.p. boilers. The electric current generated is utilized in lighting the borough.

The destructor was placed in operation about the middle of April, last, and since then has been successfully destroying all the refuse brought to it, in quantities averaging about thirty 1,500-lb. loads a day. This amount of refuse has usually been burned in 10 to 12 hr., giving an average burning capacity to the destructor of about 4,500 lb., or a little more than 2 tons an hour. The following details from a test of the combined plant made recently by Messrs. Ross & Holgate, consulting engineers for the borough during the design and construction of the plant, show the usual method of operation, the character of the refuse burned and the results obtained from the installation.

The test lasted about 8.5 hr., during which time 37,550 lb. of unscreened ashes, refuse, rubbish, garbage, manure and other wastes were consumed. The grate surface of the destructor being 75 sq. ft. this is equal to 58.7 lb. of refuse consumed per square foot of grate surface per hour. The refuse consumed during this time was 65 per cent. anthracite coal ashes, unburnt coal cinders and similar wastes; 15 per cent. garbage, manure and leaves; 15 per cent. paper, old furniture, sticks and the like, and 5 per cent. iron, bottles, tins, leather and wood. The weight of the clinker remaining was 15,880 lb., or 42.1 per cent. of the refuse fired in the destructor.

Storage Hopper over Charging Doors.

Fronts of Destructor Settings

The total quantity of water evaporated in the boilers during the test was 41,991 lb., or 1.12 lb. of water per pound of refuse burned, or considering the water evaporated from and at 212° Fahr., 1.36 lb of water per pound of refuse.

The average temperature of the outside air during the test was 55° Fahr The average temperature of the combustion chamber, as determined with a Watkins heat recorder, was 1,994° Fahr.; highest temperature in this chamber was 2,318° Fahr. and the lowest 1,742° Fahr. The average temperature of the air entering the regenerator was 75° Fehr., and its average temperature on leaving the regenerator was 206° Fahr. The average temperature of the gases entering and leaving the regenerator was 427.5° and 333.7° Fahr., respectively. The average temperature of the feed water supplied to the boilers was 47° Fahr. The average steam pressure in the boilers was 123.5 lb. per square inch.

The grates were each clinkered three times, 2 hr. 48 min. elapsing between the clinkerings, which required 10.5 min.

A delay of about three-quarters of an hour was caused by non-delivery of garbage in the early part of the afternoon of the test, during which time no fresh charge was added to the fire. Had this not been the case the engineers state in their report that the total quantity of refuse could easily have been destroyed within 8 hr., as the fires had to be held back somewhat on this account. They are also of the opinion that a somewhat better showing could have been made in the burning powers of the destructor had sufficient garbage been delivered to force it to its utmost capacity.

Some idea of the great heat generated when the fires were in full blast is said to be obtained from the fact that at one time a piece of copper tubing 1½ in. long x 1 in. in diameter and 3-32 in. thick was completely volatilized in one minute and fifteen seconds on being placed in the combustion chamber, and a wrought-iron horseshoe picked out from the clinker heap was fused in several places. (Wrought iron fuses at 2,912° Fahr.) The same thing happened to an earthenware pot made of refractory material.

The clinker produced was hard and vitreous, and was fused into large masses of great density. Almost no smoke was visible from the top of the stack and all noxious gases were absent.

The analysis of the flue gases showed the average percentage of CO_2 to be 10.9 per cent., demonstrating the completeness of the combustion. During the process of clinkering, when the large doors of the furnaces were open a large amount of air was admitted and the CO_2 fell to 4.5 per cent. of the flue gases.

From the results of the test, Messrs. Ross & Holgate say they are of the opinion that the destructor has fulfilled all the requirements of the specifications prepared by them. They also consider the test to have demonstrated the makers' guarantees satisfactorily and recommended the acceptance of the destructor.

Mr. F. B. Brown was engineer in charge for Messrs. Ross & Holgate during the construction of the plant. Mr. H. A. Garratt was the constructing and erecting engineer for Meldrum Bros. Col. W. F. Morse, of New York City, is the American representative of Meldrum Bros.

A 140-TON FLOATING CRANE is in use at Wallsend-on-Tyne, England, for lifting boilers and machinery parts into vessels. It consists of a four-screw self-propelling pontoon with tilting shear-legs, by means of which 140 tons may be lifted at a maximum outreach beyond the side of the pontoon of 44 ft.

Mistakes in Waterproofing.

Abstract of a paper read before the American Society for Testing Materials by Edward W. DeKnight.

Waterproof engineering is wholly a modern profession. Its field is the designing of structures to properly receive waterproofing. In the broader sense, its mission is the safety and preservation of structures, and the conservation of public health. Waterproofing is, itself, practically a modern art. Only in recent years has there been an earnest effort to place it on a scientific basis and deduce any system of practice. Old-school methods are as unfitted for present-day construction as the bridges of twenty years ago are unfitted for the modern locomotive.

The majority of engineers and architects still follow old-school methods, believe that concrete is waterproof—especially if it be reinforced—and give no special attention to the importance of design. A faulty design will invalidate the best methods and materials. This is particularly so in bridge work; if the bridge is not properly designed to receive waterproofing, it is almost impossible to make the deck or floor watertight.

It is a mistake to use a set design or specification for general work. Each condition has its characteristics, and should be carefully considered, especially with reference to the nature of the climate, water, soil, rock, water-pressure, use of the structure, and other conditions.

The mistake is always in asking, not how much, but how little waterproofing can be used. Contemplate using but four layers of the usual waterproofing materials in work so important, when not fewer than six or eight should be used. Nothing in construction work pays better than good waterproofing. Insufficient, weak, defective waterproofing is a thousand times worse than no waterproofing. The vital work of rapid transit subway or tunnel waterproofing is, as a rule, done half way, with insufficient headroom or other provision for properly installing the waterproofing. The usual cause is that tunnel owners, through false economy, fail to make the necessary appropriation. At the end of ten years they will regret not having doubly provided for and reinforced the entire waterproofing, bottom, sides and top.

The writer firmly believes that no material should be used for waterproofing which is not elastic. He also as firmly believes that no material should be used for waterproofing which becomes hard or vitreous. These two facts seem so self-evident that they will in time, no doubt, be taken as accepted principles.

There is in all nature, no waterproofing which is hard. The writer thinks it a serious mistake, therefore, to attempt to waterproof concrete by hardening the surface, or by using thereon a cement-plaster. We know that this method of attempting to waterproof, possesses attractive features which appeal to many engineers and architects; but nothwithstanding this fact, our personal opinion is that these features are misleading. The writer is a representative of the school of elastic waterproofing as opposed to the school of hard, vitreous or rigid waterproofing. The writer in expressing, based on tests and general experience, his own opinions, for which of course the Society is in no sense responsible, is very sincere in opposing the principle of rigidity in waterproofing, which he thinks is dangerous and will, in its practice, eventually end disastrously. It is not opposition to material but to method.

The fact that the method may have in certain cases served well for several years misleads one into using it for permanent work. By the very nature of a hard surface, that surface must serve for a while, but also by that very hardness will the waterproof value of the surface to be destroyed. Waterproofing is not what it is to-day, but what it is many years hence.

We are told that the hardening process, or the cement plaster method, must be applied to the inside surface of the wall, where it can be easily reached and the cracks patched. Patching is not perfection. Waterproofing must not crack; if elastic, it will not crack. Anyone recommending the application of waterproofing on the interior surface of a foundation wall certainly knows little of the right theory of waterproofing. It is against common sense and the logic of things to place the waterproofing in front (where in time it can be pushed off) of the line of resistance (the wall) instead of behind it. One of the chief uses of waterproofing is to keep water entirely from the wall, instead of allowing it to come to and through it, and by capillarity work up and saturate the entire wall, resulting in the course of years in the hardened cement, or even paint coating on the other side, being pressed off.

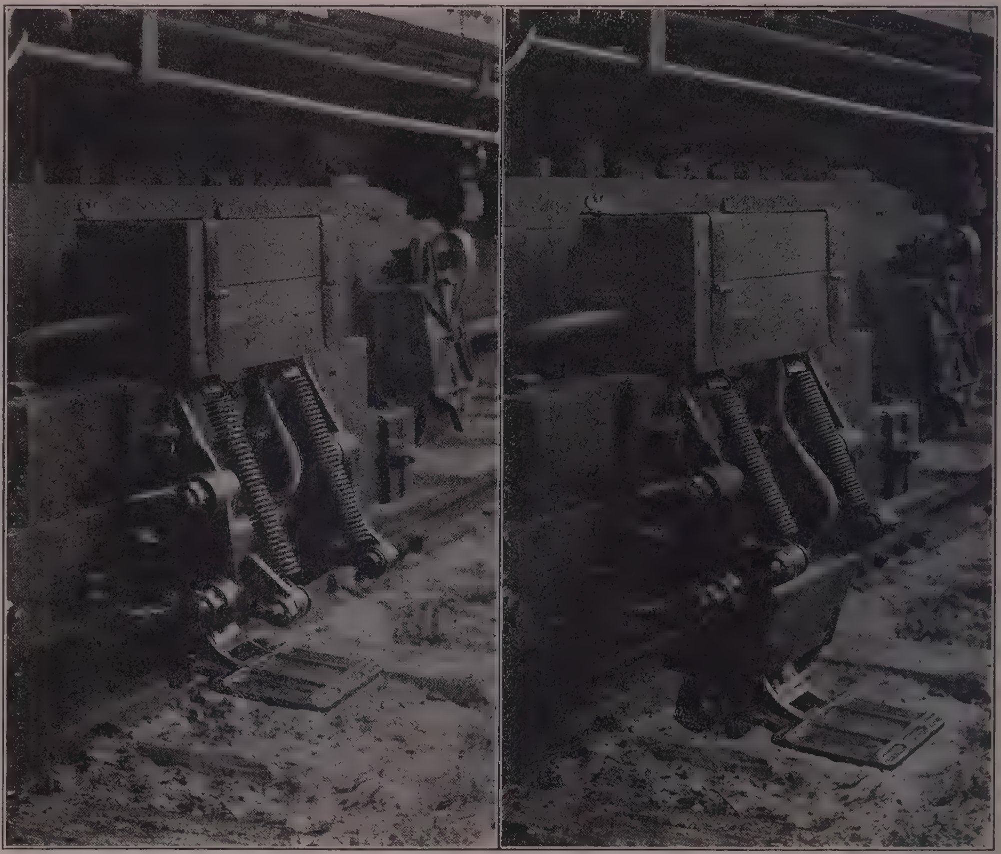
Another thing, water should not be fought; it must be led. Waterproofing is part of the general scheme of drainage. Its purpose is to check water, to lead it, and direct its flow naturally to some point where it can be disposed of through properly arranged drains. Water will always find the weakest spot in the strongest cement, though it may travel a long way and take a long time to do it. The cement plaster theory seems to have no bearing whatever on drainage. It means the fighting of water, and from the wrong side of the wall. The hardness of the plaster may keep back water for several years, but it must in time come through and the cement come off.

Even though the coating or the cement be placed on the outside of the wall, where it then cannot be readily reached to patch cracks, it will, in the majority of cases, eventually crack because, being set, hard and rigid, it cannot accommodate itself to contraction and expansion. It could not possibly be used on a bridge floor as the vibration would destroy it, nor can it be used on a roof.

It may be possible to make a cement briquette impervious to water, but it is impossible to extend this briquette into monolithic form and obtain permanently watertight results. A laboratory test of briquettes in this respect, or the test of a specially treated cement box filled with water and remaining watertight, while showing that cement in itself can be made impervious to water, is not, the writer believes, of any real value for practical work, since the conditions are altogether different. Masses of cement are subject to certain climatic changes, shocks, jars, vibrations, settling, expansion and contraction, which will negative any test of the waterproofness of simply the specially treated cement itself in small, briquette form. We condemn not a material, but a method, and judge it not by laboratory experiments or exceptional cases where it has served, but from the viewpoint of existing conditions and general work.

We believe that the principle of rigidity in waterproofing goes backward instead of forward. Mastics (composed of asphalt or coal tar pitch mixed with sand, etc.) are, for example, more yielding for waterproofing than cement coatings. Yet experience shows that almost invariably even mastics will, in cold weather, crack clear through with any settling, or expansion and contraction.

Burlap is frequently incorporated to prevent this very cracking; but experience also plentifully shows that this method—not the material, please note—is not dependable, because cracks will still occur and the burlap, not being waterproof, of course, permits the water to pass through. In many cases, tar paper is used instead of burlap.



Adjustable Third-Rail Shoe of Long Island R. R Car in Inner and Outer Positions.

There being in all nature no waterproofing which is hard or rigid, the elastic method of waterproofing seems to be as near a natural waterproofing as it is possible to devise. The elastic waterproofing is not confined to one, but may be composed of many suitable materials. It may be described as follows: It should resemble a membrane or skin; be, in itself, that is, in one sheet, absolutely impervious to water; be flexible, tough and elastic; be made of materials specially made to withstand the injurious action of water and all underground conditions. As many sheets or layers of this impervious membrane or skin should be cemented or veneered together, as the conditions require. This stratum of waterproofing when in place must be independent of, a thing apart from, the surface or structure waterproofed, which may vibrate or settle, twist or crack, expand and contract, without in the least affecting it, exactly as the hide of a horse or the skin of one's hand is free and independent of the surrounding tissue so that it may readily and naturally yield to every move of the body or the hand. This principle of elasticity, coupled with independence of movement, in waterproofing was termed by the writer some time ago as the "Improved Membrane Method," to distinguish it from the old-school process of sticking the waterproofing fast to everything to be waterproofed.

It is a question of method, and, as can be readily observed, is diametrically the opposite of the principle of rigidity in waterproofing, no matter what may be the materials.

A common and serious mistake in the application of waterproofing materials is in attempting to do the work with incompetent and inexperienced men. The average contractor will try to do the work with his own men, usually ordinary laborers, or will sublet it to a roofer, but roofing is not waterproofing. The average roofer thinks he knows how to waterproof, but unless he has many times had the actual experience he knows really little of good waterproofing. It takes more time and patience than roofing, the method of applying the materials is quite different, and if rightly done should receive much higher pay than roofing, which is ordinarily a very simple and easy operation. Waterproofing, however, especially water-pressure work, requires not alone skilled labor, but frequently considerable engineering skill.

In applying waterproofing, success depends on the perfection of every detail. The best materials, imperfectly applied, are worthless. The smallest hole caused by a dropped axe, crowbar or other tool, unseen and covered, may, after the pumps are stopped, ruin the entire work.

It is a mistake not to place in charge of the waterproofing an inspector who thoroughly understands such work. It is also a mistake to leave the work to the contractor. The preparation of the surface to be waterproofed so that it be perfectly smooth is important, as is also the careful protection of the waterproofing until it is completed and until the permanent protection is placed upon it. A very serious mistake is in not properly sloping a flat surface to drains, since water must be kept moving.

New Steel Cars for the Long Island R. R.

The design of the car equipment of the electrically-operated portions of the Long Island R. R. was based on a careful study of the traffic conditions, which require trains with the number of cars varying from two to six per train at different hours of the day, in regular operation, while heavy excursion travel to the resorts along the beaches occasionally requires trains of ten or twelve cars. It was deemed of the greatest importance to provide a single type of equipment that should be uniformly available for these varying conditions of train service.

The fact that the Atlantic Ave. division of this railroad is partly in a subway, and the need of interchangeability with the rolling stock of the Interborough Rapid Transit Subway, had much to do with the design of the cars. The complete success of the first all-steel passenger cars ever built, which were used in the New York Subway, favored their use on this road as well. To the Interborough Rapid Transit Co. and the Long Island Railroad Co. belong, therefore, the distinction of being the first railroads to adopt this radical departure in car construction. The incidental advantages of these steel over wooden cars in superior strength and durability are, of course, likewise of importance. As the Long Island R. R. cars were obliged to meet very similar conditions, both as to the physical nature of the route to be traversed and the class of travel to be handled, they were built along practically the same lines as the above mentioned steel cars for the New York Subway. In fact, except for the steps, which are made necessary by the low platforms at stations in the suburban districts, the steel car bodies are practically identical with those designed for the New York Subway.

The principal dimensions of the steel car bodies are as follows: Length over body corner posts, 41 ft. ½ in.; length over draw-bars, 51 ft. 4 in.; width over sheathing, 8 ft. 7 in.; width over window sills, 9 ft. ½ in.; height from under side of sill to top of plate, 7 ft. 1 in.; height from under side of center sill to top of roof, 8 ft. 9¼ in.; height from top of rail to under side of sill at truck center (car light), 3 ft. 3⅝ in.; and height from top of rail to top of roof with car light, 12 ft. ¾ in. The principal dimensions of the steel trailer cars are the same as those for motor cars, and they may, if desired, be readily converted into motor cars.

New Steel Passenger Car for the Long Island R. R.

While the formation of the car body is practically identical with the conventional type of steam railroad coach, the adoption of steel as the constructive material is responsible for some differences in the general designs of car framing that have hitherto followed in wooden car construction. Most of the standard parts in the framing of the wooden cars have their counterparts in the framing of the steel car.

The center sills consist of two heavy I-beams which are continuous between the platform end sills. The side sills are of heavy angles. Two extra sills, extending back to the body bolster, and composed of 4 x 3-in. angles, support the vestibule platforms. The bolsters are of the built-up type, the top and bottom members being made of two rolled-steel plates. They are machined on their outer ends to fit together perfectly, the top member being bent down over the bottom member and securely bolted to it. In the space between the top and bottom members and between the center sills is placed a malleable-iron draw casting, machined so as to be a perfect fit between the bolster plates and the longitudinal sills to which it is bolted. Between the center and the side sills malleable-iron struts are inserted.

The floor framing and the method of transferring the floor load to the side trusses of the car are different from the construction hitherto followed in wooden coaches in that needle beams and longitudinal underneath trusses are not used. The belt rail, side sills, and side posts are riveted together at their intersections, making a truss of square panels so reinforced by the ⅛-in. steel-plate side sheathing of the car that they constitute a stiff truss without the necessity of diagonal bracing. Instead of needle beams and longitudinal truss rods, four sets of diagonal braces reach down from the side posts of the car below the belt rail, and are fastened to the bottom framing. These braces are concealed in the backs of the stationary cross seats, so that their presence in the car is not evident after the seats are installed. The bottom chords of the four cross trusses have riveted to them heavy steel castings which form struts between the two center sills, thus considerably increasing the stiffness of the bottom framing. The center sills are further stiffened by the introduction of the draw-castings for the attachment of the draft gear, and by the body end sill and platform end sill construction, also by numerous cross bridges. The platform end sills are of heavy angles, bent to give the proper shape, and are continuous from side to side. The vestibule end posts are fastened to them with heavy steel castings.

The flooring of the car body is of corrugated sheet iron, and is supported by the longitudinal sills and the steel-plate bridging that is riveted across the space between the sills. The corrugated sheets are provided with metal clips which are riveted to the sheets at about 10-in. centers, to secure the Monolith plastic floor upon which, after being finished, the maple floor strips are laid with brass screws. This monolithic floor is absolutely fireproof, and is laid on in the form of a cement, which, when set, has a smooth, hard finish. The wainscoting is of steel, backed by asbestos Ceilinite, so as to make it conduct heat less readily. In all, 130 motor cars and four trailers have been provided, and were built at the Berwick, Pa., shops of the American Car & Foundry Co.

The standard third-rail shoes on the Long Island R. R. cars are of the hinged-slipper type, supported on the usual wooden beam, which is clamped against the notched face of the equalizer spring seat castings, providing means for vertical adjustment. On the center of the beam is placed a 600-ampere enclosed-type fuse in a wooden box, with a hinged cover and lined with asbestos. Trains from the Brooklyn Rapid Transit Co.'s elevated lines operate over the Atlantic Ave. and Rockaway Beach divisions of the Long Island R. R., but the Rapid Transit Co.'s elevated lines have been for some years operated with their third rail 22¼ in. outside and 6 in. above the track rail, while the Long Island R. R. third rail is 26 in. out and 3½ in. up. This made it necessary to devise some form of adjustable third-rail shoe which would operate with equal facility over the third rails of both roads and be able to change from one to the other at reduced speed without requiring attention on the part of the motorman or train crew.

Such an arrangement has been worked out, and patents on it have been applied for by Mr. James C. Boyd. It consists essentially of a hinged slipper-type of shoe mounted upon a movable lug which is held in either position by means of coil springs and is actuated by an arm that engages with a stationary cam mounted alongside the track, in line with the third rail. The movement of the car past this cam in one direction changes the shoe from the inner to the outer low position, while a reverse movement of the car past the cam changes it from the outer to the inner raised position. These adjustable shoe equipments have been fitted to such cars of the Brooklyn Rapid Transit Co. as are to operate over the lines of the Long Island R. R.

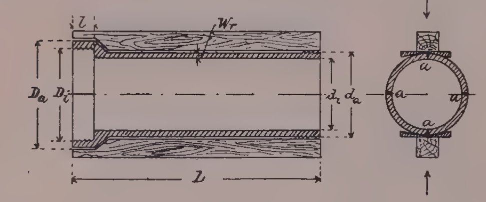
The equipment of the steel passenger cars and the auxiliary rolling stock were carried out by Westinghouse, Church, Kerr & Co., who, as in the other portions of the complete equipment, acted as constructing engineers. The entire work of design and construction was in charge of Mr. George Gibbs, chief engineer of electric traction of the Long Island R. R.

A 19-ft., 60-Ton Flywheel has recently been built for the Calumet & Hecla Mining Co., by the Nordberg Engineering Co., Milwaukee, Wis. It is designed to run at 107 r.p.m., giving a peripheral speed of nearly 6,400 ft. per minute. The wheel involves a two-piece cast-iron center held together by two steel shrink rings on the hub, four shrink rings under the rim and four T-head steel links shrunk into pockets in the rim in the usual manner. The 12 spokes are cast hollow and each has a 5-in. open-hearth steel bolt set radially into it with counter-sunk round nuts at either end, while the rim is further reinforced by two steel rings bolted against either side by fifty-eight 2-in. bolts.

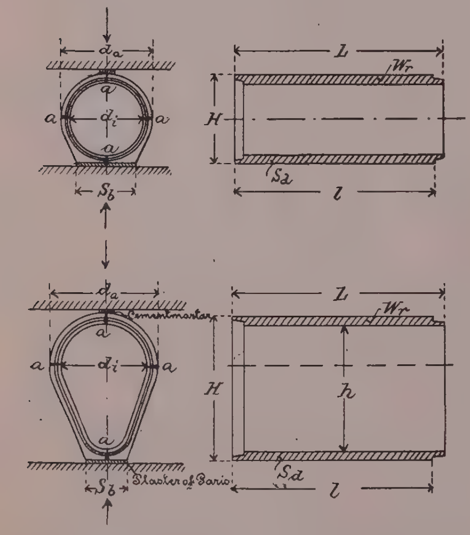
The Testing of Clay and Concrete Pipes.

By H. Burchartz.

There are scarcely any manufactured products the properties of which as regards special bearing load and resistance against mechanical stresses are less known and on which opinions are more contradictory and erroneous than in the case of clay and concrete pipes. The reasons for this are partly because so far there have been no methods of testing which would determine the strength and other properties of the materials named, in order to get uniform and reliable results and partly due to the fact that the results obtained at various places cannot be compared on account of this lack of uniformity, without even considering that such results have generally been published in a very restricted number. A report written by Messrs. Burchartz and Stock, the coworkers of the department for testing building materials and metals at the Kgl. Material-Prüfungsamt in Gross-Lichterfelde, throws some light on the actual conditions, as it specially treats the question of testing pipes, and further contains the methods for testing pipes and pipe material, now used in this testing laboratory, and the results of tests made with pipes at the said place.



Testing Arrangment of Clay Pipes.



Testing Arrangement of Concrete Pipes.

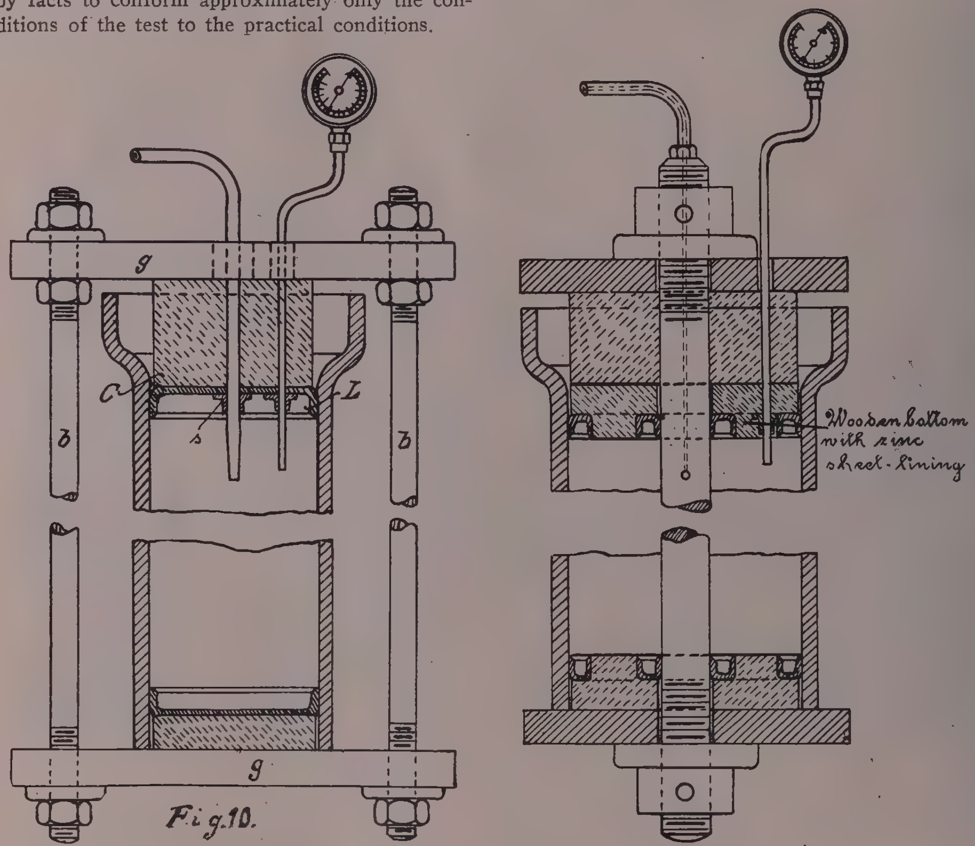


Fig. 10.

Arrangement of Specimens for Testing Resistance against Internal Pressure.

This publication is the more remarkable because for the first time the results of a considerable number of tests made on the same principle with clay and concrete pipes are brought to the public at large in a general way. As may be seen from same the test undertaken with pipes and pipe material comprises the ascertainment of the following properties: (1) Testing of the pipes. (a) Weight, shape and dimensions. (b) Resistance against external pressure. (c) Resistance against internal pressure. (2) Testing of the pipe material. (d) Structure, fracture, color. (e) Weight of volume, specific gravity, degree of density, degree of porosity. (f) Absorption. (g) Impermeability. (h) Constancy against acids. (i) Abrasion on the Bauschinger grinding disc and on the sand blast apparatus. (k) Behavior against the influence of frost. To this may be added in case the strength of the pipe materials is to be ascertained, (l) the test regarding the compressive and bending strength and in case of the manufacture of concrete or cement pipes whether the various ingredients were mixed in the prescribed proportion, (m) the determination of the mechanical composition (proportion of the mixture of cement to additional materials).

For the determination of these properties the following methods are used in the said institute: Resistance against external pressure (top pressure) and against internal pressure (water pressure). Before giving the description of the methods for determining these properties, the following general remarks may be made first. When perfecting and determining methods for ascertaining the various properties of building materials and construction parts for buildings it is fair to assume that such methods are so made that the conditions under which the test is undertaken, and the strain to which the material or part is subjected, corresponds to the real conditions and the strain in practice. It will, however, be very difficult in most cases to attain this purpose and their remains nothing else but to abide by it, which is sufficiently proven by facts to conform approximately only the conditions of the test to the practical conditions.

The first condition remaining under all circumstances is for the person carrying out the test conscientiously, to proceed at least in such a way that the result of test so made is not influenced by secondary circumstances of any kind, and that there is further a possibility of comparing the results of materials and constructions tested with each other. The test must therefore, as the writer claims, be pure and in no way be influenced in an uncontrollable degree. Clay and concrete pipes are, as is well known, not laid freely in brick canals, but are bedded in a hole dug in the earth and filled up with earth, sand, etc.; they are then, as may be required, subjected to different pressures.

In order to imitate as fully as possible the strain in such cases, by applying external pressure, it was necessary to proceed in such a way with the initial tests for determining the carrying capacity of pipes that the latter were partly or fully covered by sand or earth or bedded only to a certain height and then loaded on the top.

For the same reasons, to determine the resistance of pipes against internal water pressure, when technically testing same, the test was arranged in such a way that the two ends of the pipes were tightened by iron or wooden covers, inserting suitable joints (rubber plates) and then pressing these covers firmly against the ends of the pipes by means of nuts on threaded bolts, after which water was conducted into the interior through one cover.

Both methods for testing under internal or external pressure, however, show faults influencing the result of the test in a degree impossible to control and they are for this reason not reliable.

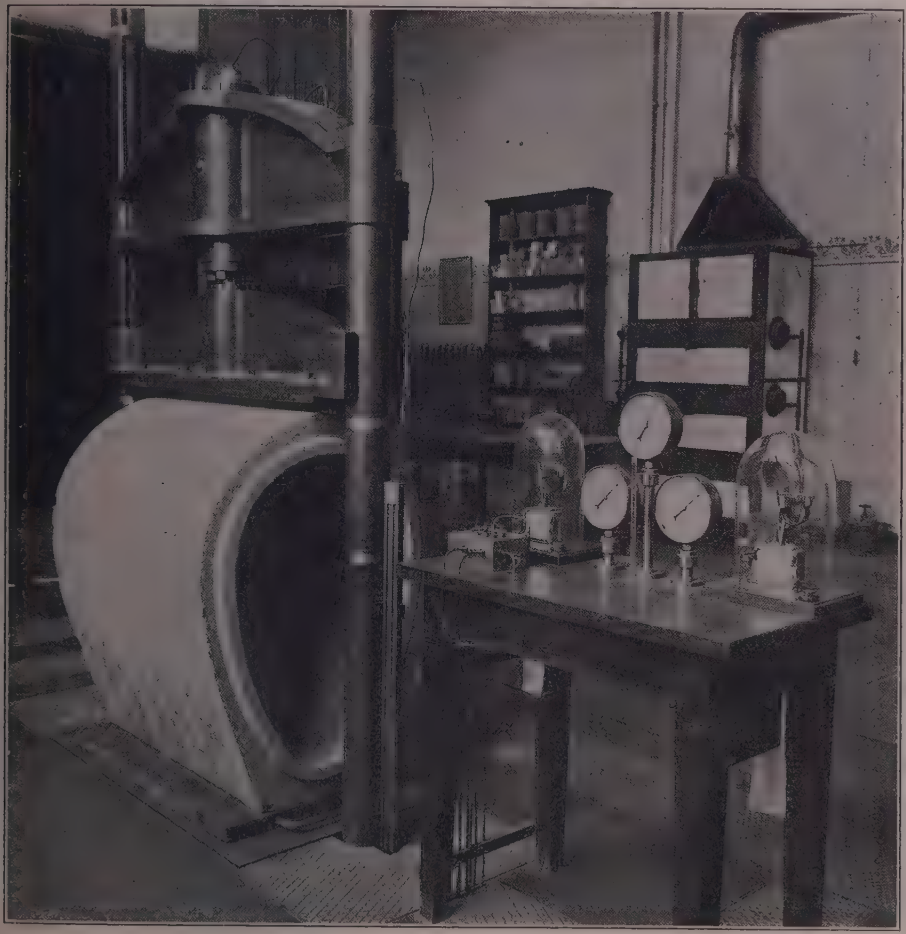
In the first case, the resistance of the pipe, not considering its own solidity, depends essentially on the sand or earth being more or less firmly tamped or on the height of filling around it, or on other circumstances influencing the test results in an uncontrollable degree.

In the second case the joint with most crooked pipes, with particular reference to clay pipes, is reached only in a very unsatisfactory manner, or the pipes when being tested are in consequence of the considerable compression, subjected to strains injuring their strength. In order to avoid as much as possible while testing the influence stated to obtain comparable results, the clay and concrete pipes are tested at Great Lichterfelde for external and internal pressure in the following manner:

Clay pipes are, as shown in two of the accompanying illustrations, placed between square pieces of pine, the ends of which have been cut out to suit the shape of the sockets. Any irregularities of the pipes are equalized as much as possible by flat wedges of soft wood placed between the pieces of wood and the pipes. The pressure is exerted in the direction of the arrows.

Concrete pipes are provided on the top with a layer of mortar or of plaster of Paris, 5 cm. broad, being exactly levelled in order that the pressure may be exerted uniformly over the whole length of the crown of pipe. When the mortar has sufficiently hardened the pipes are placed on a plain cast-iron base, after a layer of plaster of Paris has been placed on the latter, if necessary. The method of preparing pipes in this manner is shown in accompanying illustrations, the pressure being exerted in the direction of the arrows.

In order to exclude the influence of moisture from the result of the test, the pipes were stored in the laboratory until they were air-dried. The rupture of the clay and concrete pipes takes place more or less uniformly in such a way that the pipes are split into four parts at the points *a*, in other words where the greatest tensile stress is exerted. The results of the compression test are indicated in kilos as total breaking load. For determining the top pressure a pipe press having a capacity of 20 tons, built by Mr. A. Borsig and designed by Professor Martens, is used, this press permitting pipes of the largest standard sizes to be tested. The press, shown in one of the illustrations, consists principally of the tie rods securely attached to the base plate carrying in the upper part the removable traverse with the hydraulic press. Attached to the press is the traverse which distributes the pressure uniformly over the whole length of the specimen by means of ball bearings. The traverse is adjustable by inserting suitable pieces to obtain the height required. The machine is driven by hydraulic pressure and actuated by the gearing table placed at the side.


Hydraulic Press Used for Compression Tests.

The pressure exerted in the hydraulic press is transmitted by the pipe under test on the base plate, being placed on two hydraulic measuring diaphragms. The pressure exerted in these measuring boxes is indicated by the pressure gauge and is represented graphically by two automatic apparatus, both placed on the gearing table. The gauges are equipped with maximum pointers, which show the movements of the measuring box covers. The press with a specimen of concrete pipe in place for testing is shown in one of the illustrations. Measurements of deformations, made only on cement pipes, are not taken as a rule during the test, but it is easy to proceed with same by means of the pointer apparatus system designed by Professor Martens, which consists merely of two planed laths, wire nails, rubber pipes, a roller with pointer and paper and a scale. The apparatus is set in the pipe to be tested by means of the two sharpened lath ends, two pieces always being used in order to measure the deformations in both directions. The ratio of gearing can be selected according to the size of roller and length of pointer; readings up to 1/1000 cm. can be easily taken.

The resistance against internal pressure is determined by a method found by Rudeloff, which contrary to the method formerly used admits of an easy but sure and reliable closure of the pipe ends by means of leather cups.

Cups made of the best grain leather, 5 to 6 mm. thick, and having a rim about 30 mm. high, the edges of which have been sharpened, are placed in the pipe ends and are supported by wooden cylinders fitting smoothly to avoid their being forced through. The specimen thus prepared is then placed, as shown in an accompanying illustration, in a frame work consisting of two tie rods *b* and two traverses *g*, which take up the surface pressure acting on the cups with cylinders. The frame work is bolted by the nuts to such an extent only that the pipe is not subjected to a longitudinal pressure, but only to an internal pressure acting radially. In order to introduce the pressure pipe and the pressure gauge pipe, the upper cup and the wooden cylinders must be drilled in two places. The cup is tightened in these places by a small cup specially fastened at these places. The interior space of the cup is filled with joiner's glue to prevent water from penetrating, chromic potash being added to the glue to raise its resistance to water. The water pressure can either be produced by means of a hand pump, or taken direct from a high-pressure water supply. This arrangement has been approved of in practical tests and been found satisfactory for testing uneven and irregular specimens such as are often found in clay pipes. Great irregularities at the joints of the pipes are equalized before testing by applying a mixture of wax and colophonium.

In the manner described above pipes of up to 19 in. diameter are tested; with pipes of larger diameter it is difficult to make the cups, and besides their purchase price is rather high, so for this reason pipes having a diameter of more than 19 in. diameter are tested differently, as shown by another illustration.

To close the pipe ends wooden bottoms lined with sheet zinc are used. They at once fit the rollers used in testing the other pipe. The joint between pipe and roller is made by U-shaped cups, consisting of a piece of rubber pipe cut longitudinally on one side. The U cups are forced on by filling them up with a solution of glue. In order to raise the elasticity of the cups it is advisable to keep the ends of the same separated by inserting small sticks until the mass has entirely congilated.

The water is led to the interior of the pipe hrough a hole drilled in the roller and the internal pressure read on the pressure gauge attached to the wooden bottom. The wooden bottoms are secured against being forced out by nuts with pressure plates attached. In this case also the bottoms are screwed up far enough to prevent the pipe being subjected to a longitudinal pressure. In the manner described pipes up to 40 in. in diameter are tested. It may be mentioned here that the U cups must be very carefully made, as otherwise the joint is unsatisfactory.

The pressure required to burst the pipe is given in atmospheres. For calculating the strain of the material the following formula $\zeta B = \frac{P\,di}{2\,Wr}$ is used as a basis; *di* being the internal diameter of pipe, *Wr* the thickness of material and *P* the internal pressure in atmpspheres, observed when the pipe breaks.

The specific gravity is determined by means of the volumetre system, devised by Messrs. Erdmenger and Mann, and the weight per volume by means of a hydrostatic scale; in both cases with dry material.

Fragments of cement pipes are tested for permeability as follows: After jointing the lateral fracture surfaces by wax, a rim of strong paper about 7 cm. high is placed around them and made water tight by colophonium and wax. In the hollow space thus formed water is poured to a height of 5 cm., observing whether water trickles through in drops or is otherwise exuded from the specimen. This observation lasts three days, if no other time is fixed. The clay pipes are considered practically water tight.

The test of constancy against acids of clay-pipe material (concrete-pipe material is not to be considered entirely acid proof) is determined first by testing the powdered material and second by testing pieces of the material as follows: Small pieces of material are crushed in a mortar and for the test that part of the material is taken, which passes a sieve with 412 meshes per square inch and which is retained on a sieve having 774 meshes per square inch. One hundred grammes of this powder are exposed 24 hours to the action of 10 per cent. hydrochloric acid, during which time it is agitated repeatedly. A certain portion of the liquid is evaporated on the warm water bath and the residue is slightly glued and weighed. The weight determined gives the amount of ingredients soluble in hydrochloric acid.

When testing pieces of the material the following procedure is carried out: First, several pieces of about the size of the hand are dipped about one-half their length in a glass partly filled with concentrated hydrochloric acid. Second, some pieces of material are put in the same way into nitro acid, composed one part of concentrated sulphuric acid and one part of concentrated nitric acid. The behavior of the specimen is observed during 14 days and any injuries taken place are noted.

The behavior of concrete material against the action of weak acids and bases is determined in the following manner: Fragments of concrete pipes of about the same size are dried and then placed into the liquids used for testing as required. After 14 days, or later if required, the specimens are weighed. Any changes in the structure of the specimens are also noted.

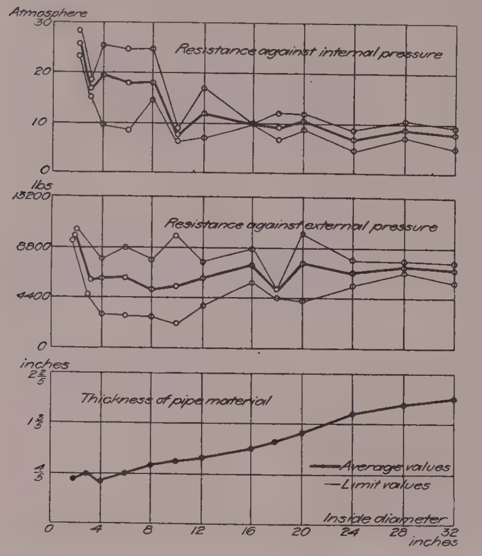


Diagram of Results in Table I.

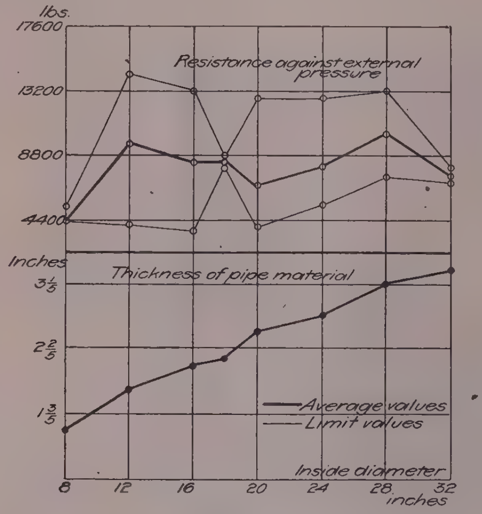


Diagram of Results in Table II.

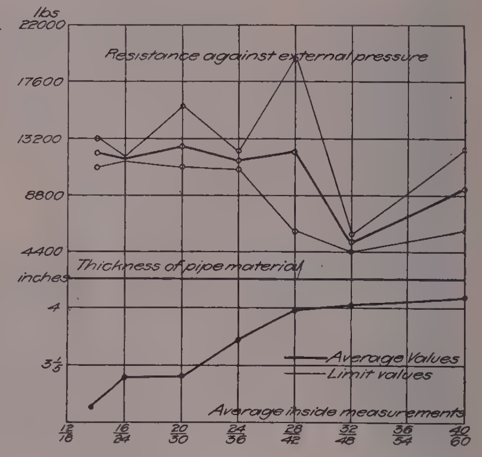
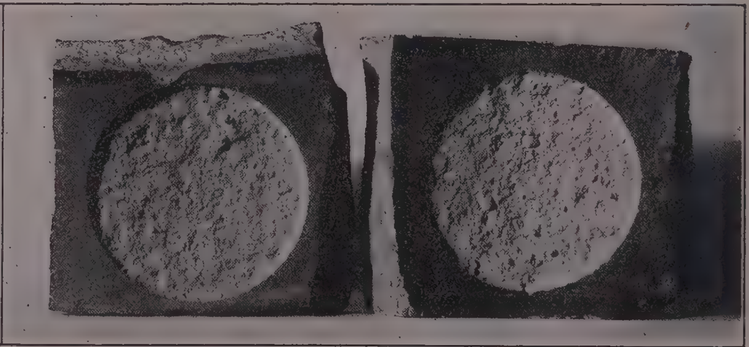


Diagram of Results in Table III.

Method of Testing for Permeability.



Clay Pipe Specimens Tested in Sand Blast.

Pipes carrying sewage are, especially when laid on steep grades, not only worn by the action of the water flowing through them, but also more especially by the grinding action caused by the sand and similar particles carried away with the water. The resistance of pipe material against abrasion is therefore of importance for the adaptability of the pipes. To determine this property the well known Bauschinger grinding method has been employed. But instead of the grinding test executed according to this method, the sand blast apparatus, described in The Engineering Record for July 14, 1906, is now used for this purpose. The latter method is suitable for specimens taken from clay or concrete pipes, more particularly because it allows the uniform treatment of the surface to be tested which is impossible to do on the Bauschinger grinding disc on account of the bend of the pipes. The action of the sand blast on samples of a clay pipe tested in the said apparatus for a period of 2 minutes is shown in one of the illustrations.

To determine the action of frost on the materials, fragments of pipe are saturated with water and alternately frozen 20 hours at 12 to 15° below Centigrade zero and thawed for 4 hours in water at room temperature 25 times.

To determine the strength of pipe material, cubes are cut out of the pipes with stone saws and tested on hydraulic presses in the usual manner, after the pressure surfaces are planed either by grinding or by placing on them a layer of cement mortar. It may be of interest to mention that the compressive strength of clay-pipe material cubes tested in the above-mentioned laboratory fluctuated in radial strain between 8,260 and 10,890 lb. per square inch and in tangential strain between 19,350 and 23,990 lb. per square inch. These figures showing the compression strength of clay-pipe material are remarkably high compared with the compressive strength of other burned products. The compression test made with concrete-pipe material averaged in two cases between 2,440 and 3,480 lb. per square inch.

In order to determine the mechanical composition, that is the mixing proportions of cement and additional material, the dried and crushed pipe material of pipe fragments is treated in diluted hydrochloric acid until all cement is dissolved. The residue not dissolved is washed and dried and out of the differences in weight first the amount of hardened cement and additional material is determined in parts of weight. From the further determination of ignition loss of the cement results the proportion between the original cement, in a state free from carbonic acid and water, and the additional material (sand, gravel, crushed stone, etc.) in parts of weight. The computation of the proportion of the concrete constituents in parts of weight to parts of volume (mostly used in practice is the mixture of constituents by volume parts) is done on the basis of the weights of volume of the cement and the additional materials. The method described can, however, be used and gives results of approximate reliability only when the additional material does not contain ingredients soluble in hydrochloric acid.

The results of tests made with clay and concrete pipes in accordance with the described methods in the Royal Testing Institute in Germany during the period of 1896 to 1904 are compiled intelligently in the above mentioned treatise, but owing to their volume they cannot be reproduced here. From the simple value that has been given it can be seen that those within the corresponding series of test differ extraordinarily, a fact which proves the necessity of extending the tests on several similar specimens, specially when testing pipes, if reliable average results shall be obtained.

The medium, minimal, maximal and average values of top compressive strength of clay pipes and of concrete pipes, so far as standard sizes both round and oval are concerned, are given in Tables I, II and III. The accompanying diagrams were made up from these values. From the diagrams it may be seen that the thickness of the pipe material grows with the increased interior pipe diameter. With oval concrete pipes the proportion of both inside measurements, D_i and h is 2:3 throughout. The strength of the pipes of equal size fluctuates within great limits both as regards top pressure and interior pressure.

The following conclusions are drawn from the results of the tests that have been made: First with regard to clay pipes (a). Without considering the exceedingly high average value for top pressure of 2-in. pipes, the average values of the other pipe diameters show proportionally low differences; they fluctuate between 4,500 and 7,720 lb. per square inch and the medium from all average values is 6,400 lb. (b) Any true relation between the values of top compression and the internal diameter cannot be deduced from the breaking loads.

(c) With pipes up to 8 in. diameter the values found for interior compressive strength are far higher than those found for pipes of larger diameter. The mean average for the former sizes amounts to 19½ atmospheres and for the latter to 9 atmospheres. (d) The mean tangential stresses B_b calculated from the average number of atmospheres for internal pressure fluctuate between 400 and 1,120 lb. per square inch, the lowest individual value being 390 and the highest 1,700 lb. per square inch.

Without regard to the low values for the 2 and 3-in. pipes and to the values for the 10-in. pipes, which are less reliable, due to the small number of individual tests, the stresses do not show great differences, 415 to 1,120 lb. per square inch; the mean stress calculated for all average values amounts to 850 lb. per square inch.

Second, with regard to concrete pipe; (a) as far as the small number of individual tests admits of a conclusion, the resistance of the concrete pipes against outside compression varies to a great extent even with pipes of equal size, as is also the case with clay pipes. (b) The average compressive strength of concrete pipes of various dimensions shows somewhat greater variations than with clay pipes; they average with round pipes between 4,560 and 10,120 lb. and with oval pipes between 9,260 and 12,540 lb. total load. The total average of the top compressive strength is with round pipes 7,790 lb. and with oval ones 11,500 lb. (c) Reliable conclusions regarding the resistance of concrete pipes against internal pressure cannot be drawn because the number of the individual tests made is too small. The maximal and minimal value found in one case each for the internal pressure amounts to 0.49 and 10.2 atmospheres.

In the case of the resistance against external pressure, the concrete pipes, as may be seen from the actual results, give with the method of testing applied generally higher average values than with clay pipes. The less favorable behavior of clay pipes compared with concrete pipes is by no means due to worse quality of material, in other words to lower compressive strength of material, but disregarding the probably greater brittleness of the clay-pipe material, especially due to the shape of clay pipes, making them more unfavorable for the strain exerted when tested under pressure. While with concrete pipes the pressure acts in the bottom of pipe on a large area, with the clay pipes the pressure is exerted on a very small area only, both in the top and bottom; besides this, with concrete pipes a larger bearing surface is created for the distribution of the load in the top by applying a layer of cement mortar 2 in. wide.

As a matter of fact, the material of clay pipes is, as proved by the results of compression tests made with clay-pipe cubes, far more solid than that of concrete pipes. Assuming even the richest mixture, best raw materials and most careful manufacture, the material of concrete pipes will scarcely obtain the least compression strength found for clay pipes, 8,260 lb. per square inch, and certainly not a compression strength of 14,200 or even 28,400 lb. per square inch, figures which have been found with clay-pipe material. The results published—and this was to be expected—show that the clay-pipe material has practically proved to be water tight and acid proof. Even the concrete-pipe material tested has been found impermeable; the pipes put under investigation were, however, as may be specially remarked, coated with tar. When exposed to the action even of weak acids the concrete-pipe material did not prove to be very resistant, as, for instance, 1½ per cent. acetic acid, and still more 1½ per cent. hydrochloric acid, exerted a rather strong dissolving influence on the cement of the concrete. In order to exclude or to reduce at least, therefore, the injuring action of acid sewage water, concrete pipes must be lined with acid-proof materials up to the height of the interior endangered by the water, or the acids contained therein must be neutralized before entering the sewer. Salts are not injurious to the concrete-pipe material.

Regarding the resistance of pipe material against wearing out, reliable data cannot be made as for the judgment of this property the results obtained do not suffice. The loss of material stated by testing with the sand blast fluctuates in the one case for clay pipes of the same origin, but different in size, 6, 10 and 16 in. internal diameter between 0.70 and 0.88 cu. in.; in the average it amounts to 0.78 cu. in., and in another case the abrasion averaged 0.71 cu. in.

Table I.

Summary of the Mean Minimal, Maximal and Average Values for Resistance against Pressure from Outside and Inside.—Clay Pipes.

		Resistance against internal pressure. Breaking load, lb.				Resistance against internal pressure. Water pressure, atm.				
Average inside diameter, in.	Av. thickness in pipe material, in.	Number of individual tests.	Average Minimal value.	Average Maximal value.	Total average.	Number of individual tests.	Average Minimal value.	Average Maximal value.	Total average.	Tangential stress lbs. per square inch.
2	0.72	3	9900	10160	9990	3	24.0	28.0	26.1	490
3	0.80	3	4140	5760	5350	3	15.0	18.4	16.3	490
4	0.68	10	2530	7590	5790	11	9.2	25.2	20.1	830
*6	0.80	31	2330	8800	5980	23	8.3	24.5	17.2	850
8	0.92	10	2530	7480	4330	13	14.6	24.2	17.9	1120
10	0.96	7	1890	9920	5100	2	6.0	8.0	7.0	600
12	1.04	17	2540	8030	5960	19	6.7	16.9	11.9	920
16	1.12	4	5720	8840	7280	2	9.4	9.7	9.6	910
18	1.28	6	4380	4620	4510	8	7.1	12.0	9.3	920
20	1.44	10	4180	10600	7720	4	9.0	12.2	10.6	1040
24	1.72	3	5390	7590	6490	7	5.3	8.6	7.2	720
28	1.88	3	6820	7590	7210	4	7.1	10.2	8.7	910
32	1.96	7	5720	7650	7000	14	5.4	9.0	7.7	1120
Average	....				6400				13.9	850

*Including pipes of 0.62 and 0.64 in. diameter.

Table II.

Summary of the Mean Minimal, Maximal and Average Values for Resistance Against Pressure from Outside.—Concrete pipes of round section.

Resistance against external pressure.			Breaking load, lbs.			
Average inside diameter, in.	Average thickness of pipe material, in.	Number of individual tests.	Average Minimal value.	Average Maximal value.	Total average.	Remarks.
8	1.40	3	4140	7240	4550	Resistance against internal pressure. Average. 8.8 atmospheres.
12	1.92	10	4160	14410	9510	0.49 " 4.3 "
16	2.16	22	3540	13240	8120	—
18	2.24	6	7990	8110	8050	—
20	2.44	21	3720	12560	6750	2.8 " 2.9 " 4.4 "
24	2.80	9	5280	12540	7960	—
28	3.20	2	7260	12980	10120	2.7 "
32	3.40	7	6780	7550	7170	—

Table III.

Summary of the Mean Minimal, Maximal and Average Values for Resistance Against Pressure from Outside—Concrete Pipes of Oval Section.

		Resistance against external pressure.	Breaking load, lb.		
Average inside measurements, in.	Average thickness of pipe material, in.	Number of individual tests.	Average Minimal value.	Average Maximal value.	Total average
14x21	2.60	2	11960	13110	12030
16x24	3.00	1	—	—	11220
20x30	3.00	11	11960	15770	12650
24x36	3.72	3	11000	11680	11350
28x42	4.00	9	6010	19450	12320
32x48	4.00	2	4360	14930	5500
40x60	5.20	2	6160	12360	9260

Testing Railway Materials by Impact is finding increasing favor owing to the peculiar operating conditions existing in railway service. Specifications for steel rails recently adopted includes a drop test requiring for 85-lb. rails and larger a weight of 2,000 lb., falling 19 ft. to strike the test rail on supports 3 ft. apart. For wheels and axles similar drop tests have been in use for a number of years, that for cast-iron wheels requiring a drop test of a 200-lb. weight falling 12 ft. for wheels of over 60,000 lb. capacity. Steel axles are tested by a 1,640-lb. weight falling 43 ft. for 40 and 50-ton axles, the centers of support being 3 ft. apart. Various drop tests are also made of draft gear and freight cars and of friction buffers, but no such test specifications have been adopted.

A Rapid Process of Bacterial Sewage Purification.

A sewage purification plant has recently been completed in connection with a sea shore resort at Skegness, England, which according to the Surveyor, reduces the tankage required to about one-fifth of that necessary for the ordinary septic tank process. The winter population of the resort is about 3,300, which is increased to 10,000 during the summer and on special occasions there are 20,000 visitors. The sewerage system provides for the house flow only, special provisions having also been made to exclude ground water. The outfall of the sewerage system ends in an ejector chamber 22 ft. deep below the surface. From this chamber the sewage is discharged through a 6-in. riser main leading to the purification works. This riser main discharges into a small grit chamber in which the heavy mineral matter is intercepted. The sewage flows from the grit chamber into a circular separating, or Dortmund, tank, 22.5 ft. in diameter, the inlet to which is submerged 11 ft. and enters in a downward direction at the center. Above the inlet level the tank is cylindrical, while below the bottom is an inverted cone. The heavy matters in the sewage containing the solids in suspension are continuously withdrawn at 19 ft. below the surface, through a dipping pipe and are conveyed into a septic tank for additional treatment. The liquid from which these matters have been drawn flows slowly upward in the separating tank and is taken off through two pipes in the center, and through numerous outlets just below the surface in the circumference of that tank. These outlets lead to a dosing chamber for two percolating filters. About 20 per cent. of the flow is taken out at the bottom and the remainder at the top of the separating tank, the clarified sewage remaining in this tank for only 1 hr., so that it is applied to the filters before much septic action has taken place.

The septic tank to whch the portion of the flow from the bottom of the separating tank is passed is 20x53 ft. in plan, and 8 ft. deep. It is uncovered and has a capacity of approximately 67,000 gal., which provides for 24-hr. storage of the portion of the sewage flow reaching it. The outlet from this tank connects with the dosing chamber and the effluents from the septic tank and the separating tanks are mingled before being applied to the filters. The septic tank also has a sludge outlet at the bottom, and an outlet at two-thirds of its depth through which the clearer liquid may be drawn.

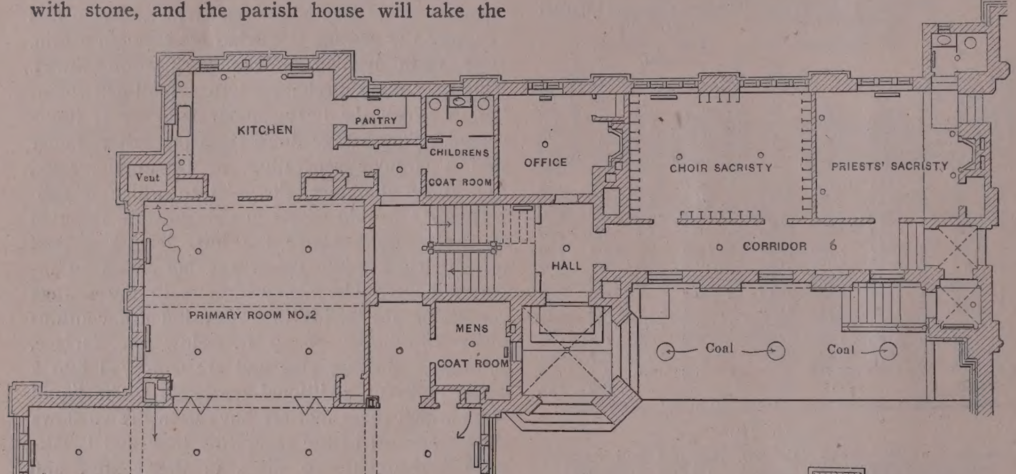
The two percolating filters, each 90 ft. in diameter and 6 ft. deep, are filled with refuse destructor clinker, with the fine material removed. The apparatus controlling the inlets to these beds is automatic and is adjusted to obtain a rest period for the filters 3 times an hour, thus greatly facilitating the aeration of the beds. The floor drains of the filters are all connected together and the outlet trapped; the upper end of the drains is connected to a flap-valve which permits the entrance, but prevents the egress of air, so that the ventilation of the beds is forced. The filtered liquid is ponded back to a height of about 6 in. by a Coleman mercurial valve at the outlet of each bed. This constant fluctuation in water level forces the air contained in the under drains and bottom course of clinker of the bed up into the body of the latter and produces effective aeration.

The effluent from the filters is said to be clear, free from odor and highly charged with nitrates. To the treatment of about 80 per cent. of the flow within about one and one half hours of its delivery to the works and to the effective aeration of the filters is ascribed the excellent effluent and the absence of objectional odor.

The Heating Plant of Calvary Church, Pittsburg.

By H. S. Knowlton.

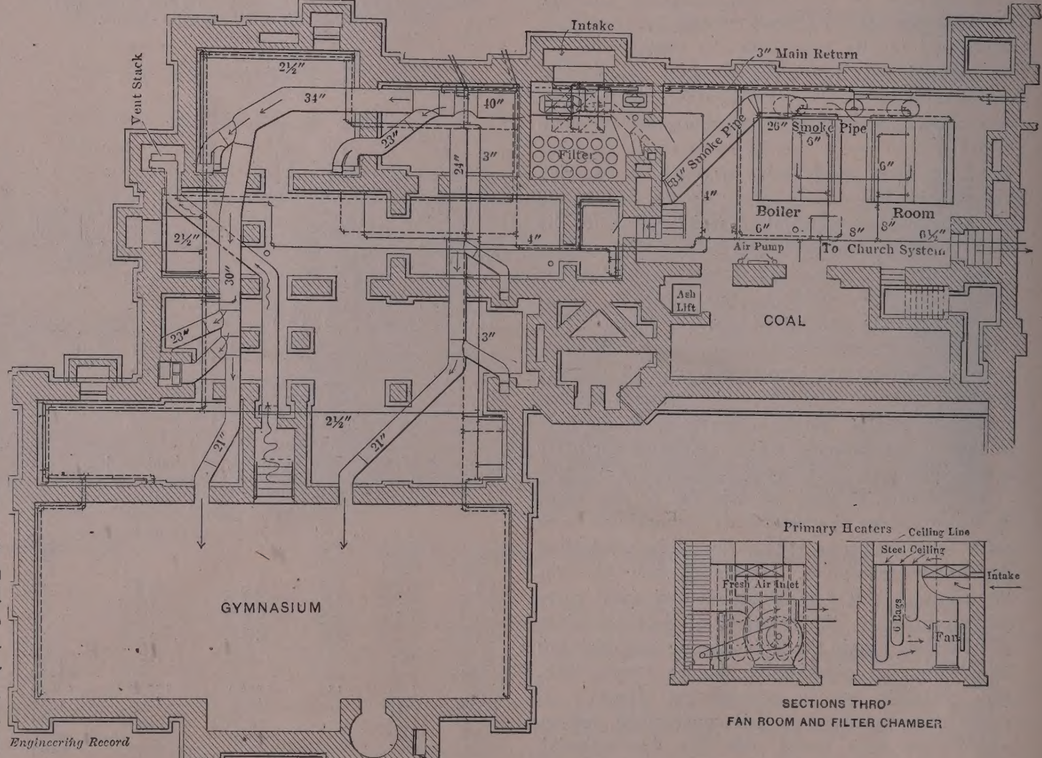
One of the largest church buildings in Pennsylvania is Calvary Church and Parish House, at Pittsburg, an Episcopal church now under construction, on the corner of Shady Ave. and Walnut St. Owing to the growth of the parish much larger facilities came to be necessary, and in order to meet the increased requirements, a new edifice was designed which is to be completed and ready for service in the spring of 1907. The church, which is designed for a seating capacity of 1,200, will have outside walls of brick, faced with stone, and the parish house will take the form of a wing, or L of brick construction with stone facing, projecting from the north side of the church proper. The completed structure will cost approximately $350,000.



Heating Arrangements on Main Floor of Parish House.

The church building proper is 212 ft. long and 108 ft. 8 in. wide, and has a tower rising midway between the north and south transepts 132 ft. high above the main floor. The parish house is about 122 ft. long and 85 ft. wide, and it will contain a sub-basement and basement with two additional stories devoted to the various Sunday-school and institutional activities of a large city parish. The heating plant is of interest on account of the flexibility of arrangement of apparatus and connections provided for meeting all operating conditions.

A combination of both direct and indirect heating is to be used for both parish house and church building. There is very little direct radiation in the church proper, while in the parish house the direct system predominates. The church and parish house are equipped with separate heat distribution systems, drawing their steam supply from a central boiler plant located in the parish house basement. All steam is supplied on the low-pressure gravity return system and the plant is guaranteed to heat all rooms to be heated, to a temperature of 70 deg. Fahr. when the outside temperature is zero. The boiler-room is about 40 ft. long and 21 ft. wide, and it contains two Mills brick set sectional boilers with 9,000 sq. ft. heating surface, supplied by the H. B. Smith Co., of Westfield, Mass. The boilers have 48x84-in. grates fitted to burn anthracite coal or natural gas as desired. Each boiler will be equipped with the usual standard fixtures, including a ¾-in. feed valve, gate and check and 1½-in. asbestos packed blow-off cock. The gauges are of Crosby pattern with 8½-in. dials, and the safety valves are 4½-in. Crosby pattern set to limit the pressure to 15 lb. per square inch. The boiler setting will be of brick laid in lime mortar. The boilers discharge their gases into a 34-in. round smoke pipe which leads to a chimney 3 ft. by 2 ft. in horizontal cross section. The damper regulator is guaranteed to hold the steam pressure within a variation of ¼ lb. The boiler blow-off tank will be 24 in. in diameter by 36 in. deep.



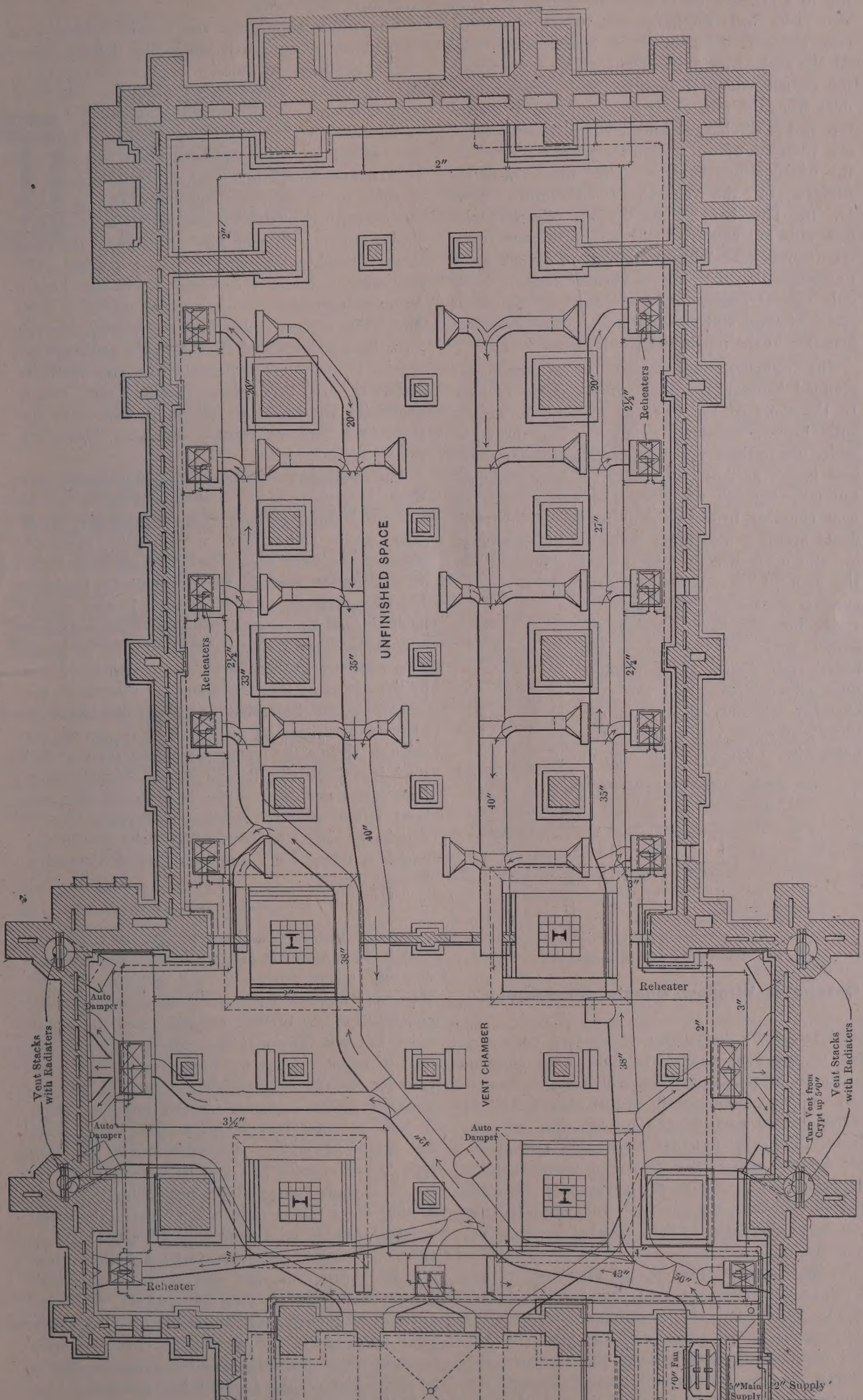
Heating Plant of Calvary Church and Parish House.

The live steam drums of the two boilers will be equalized by a 4-in. cross-connecting pipe, and the return connections are equalized in the same manner.

The parish house direct radiators are supplied with steam from the boilers through the following system of piping, as shown on the accompanying plans. A 6-in. main runs from the boilers through the boiler-room, branching first in a 4-in. line to the indirect radiator coils located in a fanroom adjoining. The main line continues from this junction as a 4-in. line, which is carried in a loop through the sub-basement, diminishing in size as branch connections are tapped off for risers. Most of the risers are of 1½-in. pipe. The sub-basement of the parish house contains a gymnasium 56 ft. 3 in. long by 23 ft. 3 in. wide, which will be heated by indirect radiation, for the reason that if direct steam heating were used, a pump would be necessary to return the drips to the boiler room on account of the low level of the gymnasium. Above the gymnasium is the Sunday-school primary room No. 1, which will be directly heated by six radiators aggregating 300 sq. ft. of heating surface, three radiators being set close to the wall in front of the windows on both the north and south sides of the room. The two-pipe system is used throughout. Primary room No. 2 is warmed by two radiators of 50 sq. ft. heating surface each, installed against the north wall. A 50 sq. ft. radiator serves the kitchen, which is 20 ft. long by 16 ft. wide. The pantry, 5 ft. 5 in. wide by 9 ft. long, is heated by a single section radiator of 7 sq. ft. The children's coat room, 8 ft. 10 in. long by 7 ft. wide, is equipped with a single radiator of 22½ sq. ft. heating surface, located near the entrance. The choir sacristy, 22 ft. 6 in. by 16 ft. 4 in., is heated by 50 sq. ft. of radiator surface, and the same provision is made for the priests' sacristy room, 20 ft. by 16 ft. 4 in. in size. The men's coat room, 9 ft. 2 in. by 8 ft. 3 in., is to be warmed by a single radiator with 16⅔ sq. ft. of surface. The halls, stairways and corridors are also provided with direct radiation, the main corridor leading to the church having 40 sq. ft. of heating surface embodied in a single radiator located about half way down the passage in front of the middle window; the corridor proper is 38 ft. 6 in. long and 6 ft. wide. In the entrance hall or vestibule of the parish house, 6 ft. 4 in. by 11 ft. 2 in., is a single 36 sq. ft. radiator just inside the west entrance. The basement stairs are provided with a 40 sq. ft. radiator located at the top of the flight.

All wall radiators are of the American Radiator Co.'s Colonial type, hung by cast-iron brackets. The total amount of direct radiating surface in the parish house is as follows: Basement, 555 sq ft.; first floor, 742 sq. ft.; second floor, 884 sq. ft.; third floor, 108 sq. ft. There are also ventilation stacks in the parish house having a total of 100 sq. ft. in radiating coils, and ventilation stacks in the church aggregating 240 sq. ft. of coil surface. In the church the direct radiation amounts to 924 sq. ft., so that the total amount of direct surface in the two buildings is 3,553 sq. ft.

Risers are run with couplings in pairs, and all run-outs and connections are made under floors except where the cutting of timbers would be necessary. The minimum grade of all pipes, for drainage, is 1 in. in 10 ft. The ends of the main supply lines are tied together and dripped to the return, Monarch steam main vents being used. The return piping is provided with draw-off connections so that any section can be drained at will. Pipes in trenches are supported on chains of ¼x2-in. wrought iron with cast-iron rollers placed at intervals not exceeding 10 ft.



Heating Apparatus in Basement of the Church Building.

The pipe covering is all four-ply sectional asbestos longitudinal air-cell type, 1 in. thick. Valves and fittings are covered with plastic asbestos cement, the latter material being also used on the boiler drums and headers. The boiler uptakes and the smoke pipe are covered with 85 per cent. magnesia blocks 1 in. thick. The steam heating system is to be controlled by the Johnson system of temperature regulation, the air compressor plant consisting of two Acme hydraulic air pumps having a capacity of 15 lb. pressure, and a 60-gal. storage tank.

The indirect system of the parish house consists of a fan and filter room on the east side with a 6 ft. by 2 ft. screened inlet for fresh air from the outside, and a duct system which carries the air through flues to radiators located in the various rooms of the building. The air enters through a primary heater containing 720 sq. ft. of radiating surface made up of 36 sections of 20 sq. ft. each, which are divided into four stacks, each hung from the ceiling by ½-in. rods with a ½x8x8-in. plate on the upper end. From the primary heater the air passes through a filter of 18 cheesecloth bags, each of which is 20 in. in diameter and hung vertically on account of the small available space. The lengths vary from 7 to 12 ft. in order to permit the free passage of air through each of the three rooms shown on the accompanying drawing. The bags are of Cabot sheeting with sewed ends. The parish house blower is a 5-ft. Sturtevant fan, full housed with a horizontal top discharge outlet 33½ in. square and one 15-in. outlet. The inlet is 42 in. in diameter and the fan is designed to be driven at a maximum speed of 230 r.p.m. by a 6½-h.-p. belted Crocker-Wheeler motor equipped with a Cutler-Hammer speed regulating rheostat. A Johnson steam jet humidifier is to be installed in connection with the tempering coil which will have a capacity to moisten the incoming air to 50 per cent. of saturation.

The main ducts in the basement of the parish house are all of round-section galvanized iron varying in diameter from 12 to 40 in., the gauge varying from 20 to 26 lb. Swinging deflections are provided in every hot air pipe. The duct system in the basement starts from the fan in a 40-in. trunk duct which is tapped near the fan by a 24-in. main running toward the gymnasium. The trunk duct thence reduces to 38 in. and gradually decreases as branches are taken off for the various flues leading to the upper rooms in the parish house until the duct finally ends at a 21-in. line at the gymnasium. The 24-in. main previously mentioned passes beneath the basement floor to the gymnasium, reaching 21 in. diameter before entering. These two 21-in. ducts furnish the gymnasium through registers located one on each side of the entrance. The exhaust ventilation system provided for the gymnasium removes air through a 24-in. round duct leading away from the entrance to a 3½x5-ft. vertical discharge flue located in the northeast corner of the building. Galvanized iron shields are provided in all ventilation stacks to protect all the openings from back drafts and aspirating coils are installed in the stacks to facilitate the discharge of vitiated air.

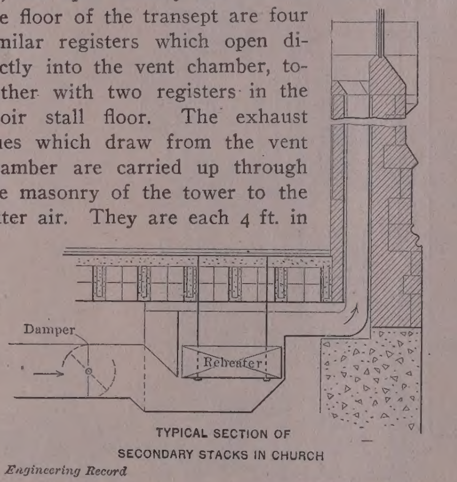
The Sunday-school primary room on the floor above is heated by two registers, one at each side of the central door, so that there is a uniform supply, either by direct or indirect radiation, on three sides of the room. The exhaust from this room is operated by the vent stack with aspirating coils, which serve the gymnasium. The kitchen is also ventilated through an outlet connected with this stack, with the addition of a special flue in the east wall for the gas stove discharge. The upper floors are ventilated by gathering ducts which lead to the trunk discharge flue, and the warm air supply is drawn from wall registers opening from the vertical ducts into each room. Primary Sunday-school No. 1 is vented by a 30x36-in. floor register, not shown on the drawings, and Primary room No. 2 by a 16x20-in. wall register. All the wall and floor registers in the parish house are of electric bronze finish. The smaller rooms in the parish house depend on direct radiation and the rector's study, on the upper floor, is fitted with an open fireplace in addition to the heating coils.

In the heating system of the church, fresh air is taken in from the rear of the building, tempered by passing through a primary radiator, and is then drawn through filter bags by a motor-driven fan and delivered to galvanized iron ducts in the basement with reheaters at points of delivery. The reheating or secondary radiators are located in the basement beneath the church windows, the air being discharged into the main auditorium of the church through the window sills, about 8 ft. above the floor for downward supply. The exhaust ventilation of the auditorium is operated through floor registers, connecting with ducts leading to a vent chamber under the central crossing; from here the air is drawn up through vent stacks in the masonry of the tower. These stacks are fitted with steam radiators arranged in circular coils, as shown in the accompanying basement plan of the church.

The fresh air inlet chamber of the church system, 5 x 8 ft. in cross-section, has two screened air openings, and is located in the northeast corner of the church basement. It connects directly into the primary heater, which contains 60 sections of school-pin radiator aggregating 1,200 sq. ft. of heating surface. The church fan is a three-quarter housed Sturtevant fan with a 7-ft. wheel, and has a top horizontal discharge outlet 4 ft. square, and a branch outlet 15 in. in diameter. The inlet is 60½ in. in diameter and the maximum speed 185 r.p.m. The fan is belt driven by a 15-h.-p. Crocker-Wheeler motor making 975 r.p.m. The fan chamber contains 28 horizontal filter bags 19 in. in diameter and 14 ft. long, and a Johnson humidifier.

From the fan a 56-in. round trunk duct leads into the basement beneath the auditorium, dividing in two main ducts, which spread out and traverse the basement throughout its length, one on each side. West of the transepts the two sides of the church are symmetrical, both in respect to supply and ventilating discharge. After the trunk duct divides, the branches proceed westward, decreasing from 42 in. in diameter as branches are taken off until the final size, ending in the branches near the vestibules, is 20 in. Each branch from the main duct is 20 in. in diameter, and it leads directly into the secondary heating coil group, and from each coil group two risers, each 8 x 24 in. in horizontal section, carry the air to the window sill openings. Beneath the main body of the church, between the transepts and the narthex, are 10 secondary heaters, five on each side. Each heater contains 13 sections of school-pin radiator coils aggregating 195 sq. ft. of heating surface. Beneath the transepts are two stacks of 21 sections each, having 315 sq. ft. of heating surface per radiator. These radiators are each fed by a 28-in. round duct, and they each discharge into three 8x28-in. risers leading to window sills. Each transept aisle has a stack of 10 sections, with 150 sq. ft. of heating surface, supplied by an 18-in. duct. The window sill risers from these radiators are two in number per stack, and have an 8x16-in. cross section. The crypt is supplied through a 19-in. duct leading to a radiator of 12 sections, 180 sq. ft., from two 14-in. ducts discharge into the crypt through two 12x24-in. inlet registers in the west wall. At the east of the north transept aisle is a morning chapel, which is supplied by a direct branch duct from the fan. This duct is 19 in. in diameter, and it discharges into a single stack secondary radiator of 20 sections, aggregating 300 sq. ft. of heating surface. The total radiating surface in the church is therefore 3,360 sq. ft. The heat inlets in the church window sills are equipped with special bronze register frames cast with deep flanges on an angle to deflect the air from a vertical course. The only special heaters in the vicinity of the choir stalls, chancel and sanctuary are direct radiators installed in the north and south ambulatories.

The exhaust duct system is symmetrically planned beneath the floor of the main church. In the floor of the nave of the church are 15 solid bronze registers, each 5 ft. long by 8 in. wide. From these registers, 20-in. gathering ducts lead into a pair of trunk ducts which run longitudinally beneath the floor and empty into the vent chamber beneath the transepts. The trunk ducts attain a maximum diameter of 40 and 46 in., and open directly into the vent chamber. In the floor of the transept are four similar registers which open directly into the vent chamber, together with two registers in the choir stall floor. The exhaust flues which draw from the vent chamber are carried up through the masonry of the tower to the outer air. They are each 4 ft. in diameter, there being one located in each corner of the vent chamber. Each duct contains 60 sq. ft. of radiating coils, which act as aspirators. Two special 20-in. vents run from the crypt, one to each of the nearest pair of riser ducts. The crypt is isolated from the vent chamber for the reason that it would be undesirable to carry the air from the crypt back into the church, although the air from the vent chamber can be re-circulated in cold weather, or if otherwise desirable.



Details of Window Supply Connections.

In the basement plan of the church is shown a return duct from the vent chamber to the fanroom. By cutting off the discharge through the vent stacks at the corners of the vent chamber and opening the return duct, the air from the church may be recirculated around through the fanroom heater, filter, fan, and through the secondary heaters to the church; this arrangement provides for heating the church quickly, as on a very cold morning, the recirculation enabling this to be done rapidly and very economically as regards fuel consumption.

A system of closed circulation can be placed in operation by opening two large dampers in the main supply ducts near the centre of the vent chamber and closing the riser dampers and return duct. The air then passes from the church to the vent chamber and back through the secondary heaters and window sill risers to the church, thus by-passing the fan and filter. All ducts are supplied with either automatic or hand-operated dampers, the automatics being controlled from the boiler-room by compressed air and three-way cocks.

The steam supply for the church radiators is carried to the church basement by a 6½-in. line which branches in smaller sizes to the various sets of coils. The primary heater is fed by a 5-in. line and a 5-in. trunk line serves the apparatus beneath the church body. The supply of live steam and the return system beneath the church are looped to give as much flexibility as possible to the piping. Two main lines of supply run beneath the body of the church longitudinally, beginning with 3-in. pipe and cross-connecting at the vestibules and narthex in a 2-in. pipe. The aspirating coils in the corner risers are heated by an independent cross-connected system of 2-in. pipe. The secondary heaters are supplied through 2-in. branch lines and the vestibule radiators by 1½-in. branches. The returns from the vestibule radiators are 1-in. pipes feeding 2-in. mains, gradually increasing to 3½-in. diameter, as the secondary radiator returns lap in. These are 1½ in. in diameter.

The radiators in the north ambulatory are three in number, two of them having 60 sq. ft. each of heating surface, and the third 100 sq. ft. The south ambulatory is similarly equipped. Each of the front vestibules has a single radiator of 114 sq. ft. heating surface, and the narthex has two radiators of this capacity, located one at each side of the central entrance. The vestibule and main doors swing in and out, and all movable windows in the church and parish house are of the casement type, swinging on a vertical axis.

Throughout the entire design the maximum air velocity permitted at any register is 300 ft. per minute. When the equipment is operating at full load it will change the air of the church about four times per hour. The heating contract has been let to Messrs. Anderson-Darragh Co., of Pittsburg. The architects of both the church and parish building are Cram, Goodhue & Ferguson, Boston, Mass.

Poppet Valves for Locomotives is a practice that is meeting with favor abroad. With the increasing steam pressures and growing use of superheat in modern locomotives, improved valve construction has become essential, and the piston valve has not fully met the requirements. A design of poppet valves has been applied to a four-cylinder balanced-compound locomotive of the Prussian State Railways, which promises fairly to have an important influence over future practice in this direction. Experience with the new type of valve which has been in successful use for about a year indicates the possibility of maintaining them steam tight when used with superheated steam to an extent impossible with piston and slide valves. Lubrication of the poppet valves is also much simpler and more economical. Steam tightness is secured without excessive friction or pressure on the seats, and extremely rapid opening and closing of ports is secured with corresponding favorable results in steam distribution. The design adopted has resulted in remarkable small cylinder clearances without impairing the convenience of accessibility to the mechanism, and the construction adopted results in offering security against water hammer by acting as spring safety valves to instantly relieve excessive pressure in the cylinders due to water. Much is, in fact, to be learned from gas engine practice in the use of poppet valves; here the conditions of operation are such, owing to the high temperatures of the cylinder gases that no other type of valve will remain tight, yet the poppet type of valve is easily maintained in tight condition.